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OUR SECOND WIND

You have probably had the pleasant experience—in sports, a research project, or some other challenging situation—of attaining some measure of success through great effort. Then, feeling that you have reached a new high, you suddenly find your "second wind" and away you go to new goals.

We in the Central Association are ready for our second wind, now. Last year, we culminated the efforts of our members and leaders over a period of fifty years with a celebration of the achievements of our Association. For fifty years, the stimulation from our membership had had a marked effect on the advancements made in the teaching science and mathematics. With Dr. Walter Carnahan spearheading the project as Editor, key people gathered together, for publication, the impressive story of the parallel development of science and mathematics education and the Central Association. The result was our Golden Book, *Fifty Years of Teaching Science and Mathematics*, a progress story of which we are justifiably proud.

It is encouraging to note, then, that after this period of achievement, our Association is getting its second wind to continue to encourage and point the way to more effective education in an era in which the breadth of scientific information has so increased that its coverage is a stupendous task. That is a challenge as we enter our second half-century.

Professional association can be helpful to you and your co-workers as you meet this challenge, and it is with this thought in mind that our section and group chairmen have planned their meetings for the Convention in Cleveland, November 22–24. They have selected outstanding people from across the nation to bring down-to-earth material for use in your classrooms and to provide leadership in discussing problems which concern you.

The general sessions, too, will be provocative of sound thinking as speakers share their experiences in national and international situations. Dr. Donald Loughridge, Reactor Division of the Atomic Energy Commission, keynotes the sessions with his revealing discussion of *Education—The Primary Atomic Control*, while at the final general meeting, Vice Admiral Harold G. Bowen, Executive Director, Thomas Alva Edison Foundation, will discuss *Foundations, Industry, and Education* in his stimulating, vitalizing manner. The colorful and informative presentation by Dr. Elvin Stakman and Dr. David Dietz will be features of great inspirational value.

Plan to meet with us at the Hollenden Hotel in Cleveland this year. The professional and social events which are planned for you will make your stay a real pleasure.

DONALD W. LENTZ, *President*

SPACE STATION COULD CIRCLE EARTH AS ARTIFICIAL MOON

In not so many years to come a giant "doughnut" 200 feet in diameter may be travelling constantly around the earth 1,075 miles up in the sky. Dr. Wernher von Braun, Army rocket expert, describes such a "space station" in the new book, *Space Medicine*, edited by Dr. John P. Marbarger, research director of the University of Illinois' Aeromedical and Physical Environment Laboratory.

Dr. von Braun was a top German World War II rocket expert, credited with inventing the V-2 rocket, who was brought to this country to work for the Army after the war.

Men will live in the outer rim of the doughnut, according to Dr. von Braun, kept in place by a synthetic "gravity" provided by its rotation slowly around the hub. It can be used to spy on both the earth and the heavens, it can drop bombs on any part of the earth, and can be used as a way station on the road to the moon.

The space station will be made of plastic, assembled in space by men in pressure suits, Dr. von Braun says. It will have spokes leading to a hub containing a spherical steam boiler. A large silvery disk on top of the hub concentrates solar heat for the boiler. With the steam, according to Dr. von Braun, a turbine may be driven for the generation of electric power.

How does this space station get 1,075 miles up into its orbit? Dr. von Braun believes that it can be carried, broken down into collapsed sections, in a three-stage rocket, which he describes.

"With the tremendous advances recently achieved in aerial defense," declares Dr. von Braun, "it appears to me that in the atomic age the nation which first owns such a bomb-dropping space station might be in a position virtually to control the earth. The political situation being what it is, with the earth divided into a western and an eastern camp, I am convinced that such a station will be the inevitable result of the present race of armaments."

PROPOSED REVISION OF BY-LAWS

ARTICLE III. Section 2. Nominees for the office of president and vice-president must have been officers and/or members of the Board of Directors within the past five years.

WHAT IS A "GOOD TEACHER"?

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Anyone who has listened to a group of secondary school or college students discuss the relative merits of a specific teacher has probably heard such remarks as: "He stinks," "She is a good teacher," "She grades too hard," or "He is too tough," etc. Upon closer follow-up one learns that an actual definition or characterization of the term "good teacher" is very difficult to express in a few words. Several sentences are required to include all desirable phrases essential for the description, and even then are not adequate for a thorough job.

Although the student usually associates a "good teacher" as an individual who has administered a satisfactory grade to him in a course, our more sincere students give the impression that scholastic rating received and personal impression of the relative merit of the teacher are not positively correlated.

As a result of several years' first-hand experience as a student, as a teacher, and currently as an outsider reviewing first hand as well as associated teacher-student experiences, it is believed that "good teachers" *have been* and *are* in evidence, and that student-body rating of staff members will probably concur, in many cases, with that of department heads and deans.

The "good teacher" is characterized as the possessor of a pleasant personality and the important faculty of understanding and appreciating student shortcomings as well as pitfalls and stumbling blocks in the learning processes. He never embarrasses a student before others by criticizing a lack of knowledge or information on a subject. Kindness, consideration, guidance and courtesy are always in evience.

He is neat (but not necessarily flashy) in appearance, kind in action and considerate of others at all times. He is punctual in class arrival, and usually remains several minutes after the end of the period, answering student questions. He is not a clock-watcher, and often may be found at his desk or laboratory during off hours as well as on days when school is not in session. He generally takes an important part in school activities, serves on faculty committees, is interested in and attends sports and athletic events, and is active in the promotion of closer student-faculty relations.

The majority of the student body admits that teachers, as a result of their training and experience, are fully familiar with their subject, although some experience more success than others in actual delivery. Knowledge of subject matter is thus usually not a variable to be

considered in judging a "good teacher." Students respect the "good teacher's" knowledge of subject matter as well as his ability to present the material in a smooth-flowing continuous developing manner. Certain students tend to impose upon his good nature by requesting (and obtaining) study-assistance conferences. A very small minority occasionally take advantage of the teacher's trusting disposition by copying from notes and by use of cribs during examinations. It is believed they do not feel overly proud of their success in these activities.

Realizing that his business day is filled to capacity, a glance at the "good teacher's" home life will usually reveal that he is interested and active in civic and church life. In addition, he has a garden and usually devotes some time to a hobby or two. He is a family man, with two to four children. He enjoys participation in community activities with the same zeal as is exhibited in the classroom. It is little wonder that an individual whose day is so filled with interests, duties and activities usually finds himself at midnight with "one or two sets of papers to be graded and recorded before nine tomorrow morning".

Our secondary school teachers form one of the more vital links in the formation, training, and molding of our future citizens. They have certain problems and duties which differ slightly from those of the college and university teachers. The extra-curricular activities of the successful secondary school teacher generally include membership in local civic organizations, membership in regional or state organizations in specific fields of interest, and usually the sponsorship of one or more student organizations such as "Biology Club," "Camera Club," "Future Citizens Club," etc.

In order to avoid loss of contact with current changes and development in his field of interest, the "good" secondary school teacher usually subscribes to several periodicals related to his field of interest. Whenever possible he attends local, regional and state meetings of organizations which are related to his teaching subject(s). In many cases one finds the "good" secondary school teacher attending a university summer session during the regular secondary school summer vacation.

At the present time many of our colleges and universities are offering specific "summer school short courses" or "secondary school teacher summer seminars," in which college faculty members present talks covering recent trends and developments in specific fields of subject matter. The "good" secondary school teacher generally takes advantage of such opportunities by attending and keeping abreast of new developments.

When one considers that the secondary school teacher has a heavy

schedule for nine months, at a salary which often is equal to, or less than, that of local tradesmen, and then utilizes a portion of his savings to pay for his attendance at conferences, meetings, etc., in order to do a better job in the future, it is readily seen that the "good" secondary school teacher is truly a remarkable individual. Perhaps his greatest reward for such earnest endeavor is to observe the progress and development of past students, who go forward to become leaders in the professional or industrial world. Although such a reward cannot be measured in terms of monetary value, the sense of satisfaction and well-being resulting from observing these effects is very gratifying.

Due to the frequent informal classroom and/or laboratory contact, combined with relatively small classes, the high school or small college teacher generally gets to know all his students by name, in the early weeks of the school year. This informality is quite impossible in the large college and university where larger, rather formal, lecture-type instruction is in evidence. The small college or junior college serves as a sort of transitional stage between the informal secondary school instruction and the more formal presentation which characterizes much of the university teaching.

Many of our smaller colleges have served at reservoirs from which our large universities draw some of their most successful graduate students (1). This fact is evidence of the existence of many "good teachers" as well as brilliant students in these less prominent institutions of higher learning. A recent report (2) includes proof to support the statement that—"the small liberal arts colleges produce more Ph.D. material, per thousand graduates, than the large universities do." Such reports are most gratifying to the teachers in the small liberal arts colleges concerned.

The "good teacher" in the small college generally has a teaching load which is comparable with that in our larger secondary schools. He subscribes to periodicals in the field of his specialization, and is also a member of related local and national societies. Whenever possible he attends regional as well as national meetings of professional organizations of interest. Due to limitations in financial budget as well as in laboratory space, the teacher in the small college generally has but a limited opportunity for undertaking original research investigations. His efforts in "research" are generally limited to statistical studies of student performance, classroom or lecture demonstrations, preparation of standard tests, and other items related to the teaching and learning processes. In only a few cases does one find frequent reports and publications containing original studies from staff members of small liberal arts colleges.

In our larger colleges and universities, the "good teacher" also

realizes what it is to have a never-ending day. He is equally as active as his small college or high school colleague in terms of civic affairs, hobbies, and church groups. He is likewise a member of local as well as national organizations in his field of specialization. Furthermore, he feels somewhat obligated to attend regional as well as national meetings of these organizations, and in many cases he must pay part or all of the associated financial burden.

Administrative officers of our larger colleges and universities generally advise their faculty members to become active in some sort of research program which will lead to publication of results in technical journals. Such reports contribute to the fame of both the school and the teacher concerned. Teaching loads (clock hours per week) of certain of the larger universities are often intentionally reduced to enable staff members to embark on research studies.

This trend toward encouragement of original research is more evident in our larger colleges and universities than in the small colleges and normal schools. Certain schools have "academic" or teaching faculties, and in addition have "research" faculties. The academic staff is primarily concerned with teaching course-work while supervising but a small amount of research. On the other hand, the research staff is primarily concerned with conducting and supervising research, with little or no formal instruction expected. In some institutions academic promotions often bear a direct relationship to the number and type of papers published by the staff members concerned (3). If the already full day of our "good teacher" should be further loaded by suggesting that he undertake to supervise a research study in the field of his interest, it is quite obvious that he will have to reduce the time formerly devoted to other interests, if he concedes. Perhaps it will be his garden, his church, or his sports interests which he will neglect in favor of the research program. It is also possible that he may have to curtail certain of his student contacts in order to accommodate this new activity. No doubt the man is often as interested in research as he is in teaching, but the efficient coverage of both fields is virtually an impossibility in a 24-hour day or a 168-hour week. It is firmly believed that the subdivision of a school faculty into the "research" and "academic" staff, with specific duties assigned to each, or the reduction of the academic load of members who express a desire for investigational work, is essential for the efficient instructional programs in our schools. Good teaching has as great a reflection upon the life and productivity of an academic institution as do a multitude of technical publications. The ideal situation involves both.

Certain of our successful students in university graduate schools have received their undergraduate training in small colleges (1–2).

In many cases they are as successful as others who received their undergraduate training in a large school. This fact indicates that the caliber of instruction in certain of our smaller schools is equivalent (or superior) to that of many of our large colleges and universities. Obviously we have "good teachers" in both types of institutions.

Dr. A. S. Richardson has recently stressed the need for more awards in teaching (3), and has stated that in addition to public recognition—"there can be no greater honor than to be classed as a great teacher in the mature judgment of his students."

It is sincerely hoped that the recently established Scientific Apparatus Makers Award in Chemical Education (4) will focus the spotlight of interest on certain of our faculty members who qualify sincerely and wholeheartedly as being "good chemistry teachers."

References

(1) "The Role of the Liberal Arts College in the Professional Training of Chemists," H. F. Lewis, *J. Chem. Educ.*, *28*, 104 (1951).
(2) "The Origin of United States Scientists," H. B. Goodrich, R. H. Knapp, and A. W. Boehm, *Sci. Amer.*, *185*, No. 1, 15 (1951).
(3) "Foundations of Chemistry," A. S. Richardson, *Chem. and Eng. News*, *29*, 2134 (1951).
(4) ACS Board of Directors, Minutes of Meeting, June 8, 1950. *Chem. and Eng. News*, *28*, 2512 (1950).

A MODEL SCHOOL BUILDING

The school that makes the teacher's dream come true now exists—fully photographed, analyzed and blueprinted in the pages of the September issue of *Popular Science Monthly* magazine. Based upon an actual new elementary school just completed in New Canaan, Connecticut, it incorporates in one master plan all its remarkable advances in school plant design, plus other architects' contributions. This model school is completely unique in that it was devised for just one purpose—to meet all the requirements of actual classroom use by teachers and, by so doing, to serve better both pupils and the community at large. Every aspect of this school reflects teachers' wants as revealed in a nation-wide recent survey by the Public Education Association. Point-by-point the "ideal school" is examined and explained in a full-length, lavishly illustrated article in *Popular Science*.

Projected for a full enrollment of 450 children from kindergarten through sixth grade, the model school embodies dozens of up-to-date improvements in lighting, heating, building materials and homelike decoration. Washable walls, bright color schemes, glass block panels, prefab construction—these and many other fruits of scientific and industrial research are included. Other features are drawn from the exemplary South Elementary School in New Canaan, Conn.

With over seven million more children reaching school age in the next decade, school construction will be a major item in every community's budget. Every educator will want to read this important September *Popular Science* article which makes concrete, progressive proposals on modern schools from the standpoint, not of architects, taxpayers or parents, but of the teacher who spends most of his or her working life in the building.

NOTE ON INTEGRATION BY PARTS

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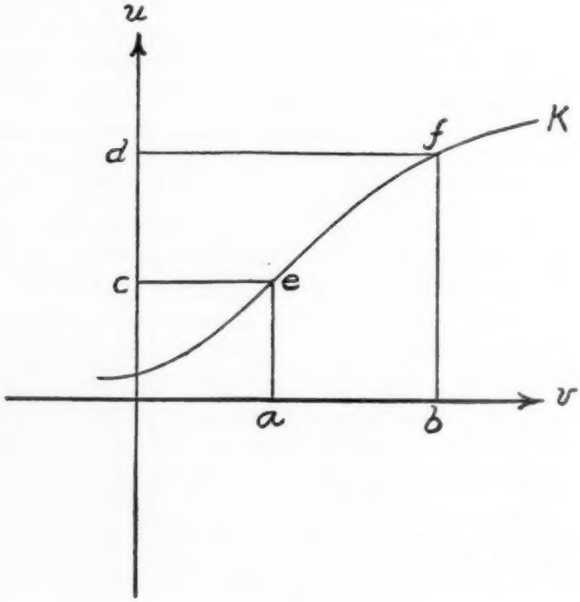
Let v, u be the coordinates of a variable point on the continuous curve K in the figure. If we evaluate

$$\int_a^b u\,dv$$

by using integration by parts, we have

$$\begin{aligned}\int_a^b u\,dv &= \left[uv - \int v\,du\right]_{v=a}^{v=b},\\ &= \left[uv\right]_{v=a}^{v=b} - \left[\int v\,du\right]_{v=a}^{v=b},\\ &= db - ca - \int_c^d v\,du,\end{aligned}$$

since u is equal to d when v is equal to b, and u is equal to c when v is equal to a from the figure. But $\int_a^b u\,dv$ is the area *abfe* under K, $\int_c^d v\,du$ is the area *cefd* to the left of K, and $db - ca$ is the area of the L-shaped region *abfdce*. Thus we have a geometric interpretation of integration by parts.



CREATIVE ACTIVITIES IN NUCLEONICS

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"IDEAS ARE AMMUNITION"

The purpose of this article is to present some activity ideas organized to assist in teaching certain abstract concepts of nuclear energy in such a way as to provide the student with creative experiences.

The activities to be discussed are of a laboratory exercise nature and are to be executed by the student. They can be designed to be a creative activity as well as an experience in science. The activities could be adapted, too, to demonstration procedures. As such they would aid in teaching the nuclear energy concepts with which they deal, but they would, of course, lose whatever values they possess as creative projects.

Most of the concepts of the science of nuclear energy are abstract. Any device that will substitute concrete things for the abstract concepts will make the nuclear processes more meaningful to the student. He can actually feel the articles and see the processes.

There is a wealth of material dealing with the scientific aspects of nuclear energy, as well as its social impact. Such items as films, filmstrips, and pamphlets, as well as articles in the popular periodicals, books, and charts, are readily available to the classroom teacher. However, in the laboratory the situation is different. Most high schools will not have a Geiger counter, or a Wilson cloud chamber, to say nothing of a mass spectrograph or a cyclotron. The possibilities for student development through laboratory activities and experiences in this field are as great as in any, but few schools are equipped to provide them, except, as will be suggested here, by methods of simulation and analogy.

"COOK-BOOK" OR CREATIVE?

The conventional, detailed-instruction, type of laboratory exercise, or "experiment," as found in the usual laboratory manual does little to encourage original thinking on the part of the student. He is not challenged to exert his ingenuity by step-by-step directions, nor by the type of "experiment" in which he is asked to "fill in the blanks," or "label the diagram."

In the sample laboratory exercises that follow in the next section an attempt has been made to set the stage for ideas, rather than to present the ideas directly. The student is expected to get his own ideas and carry them out. Naturally some students will require more

help, more clues or hints, than others, but even the slowest should be able to contribute something from his own thinking.

The exercise will provide experience in creative thinking, thinking on the frontier of the student's knowledge. An experience more typical of the experiences of the investigators in science would be hard to find. Creative thinking is the essence of science, of scientific development and progress. That the student will discover nothing really new is true, but he may discover something new *to him;* to him, such an experience can be just as thrilling as if he had turned up something really original.

To provide the student with the materials with which to build a creative-thinking experience, to give him the satisfaction of working out his own problems, is more important than to equip him with "cook-book" instructions in order to assure correct results.

Neutrons for Nuclear Bullets; Why?

The following is a laboratory exercise designed to encourage creative thinking on the part of the student. Remember that a student (or a group) may need more help than is given here. This sample exercise may serve to give the reader an idea of how something similar might be designed to meet the needs of his particular class in physics, chemistry, or physical science.

A. *Problem:* To devise and execute an exercise that will illustrate why neutrons make better "nuclear bullets" than do alpha particles.
B. *Answer the following questions; use text if necessary:*
   1. What are the electrical properties of neutrons and alpha particles?
   2. In general, what is the structure of the uranium atom?
   3. What are the electrical properties of the components (electrons and nucleus) of the uranium atom?
C. *Equipment:*
   1. Steel balls (ball bearings).
   2. Glass marbles of about the same size.
   3. About 16 magnets, bar or horseshoe, or both.
   4. A trough made of heavy paper, which can be inclined slightly, in which the balls and marbles can readily roll.
D. Using the equipment listed above, work out on paper an exercise that will show why neutrons make better nuclear projectiles than alpha particles do.
E. What hypothesis can you make before you begin?
F. What assumptions do you need to make?
G. Proceed with your exercise.
   1. What things do you observe?
   2. How do you explain them?
   3. Can you draw any conclusions? What are they?
   4. What assumptions have you made in stating these conclusions?
   5. What analogies have you drawn?
H. Do you see any way in which your original exercise might be improved?
I. Try the improved procedure.
J. Explain why it worked better, if it did.
K. Repeat H, I, and J above until you are satisfied you have done the best you can with the available material, and write up your exercise. Follow any organization you like, but be certain to include:

1. A discussion of how your exercise satisfies the problem stated under A;
2. The answers to the questions under B;
3. The assumptions that you must make in order to make the exercise meaningful, and the analogies you have drawn;
4. Your observations and the conclusions that logically follow.

It is probably clear to the reader what is expected of the students in the foregoing exercise. After familiarizing themselves with the points emphasized under B they are to take the equipment and set up an exercise, first on paper, then with the equipment, that will illustrate the reasons neutrons are better suited for nuclear projectiles than are alpha particles. This allows them some degree of originality, or creativeness, in working out a solution to the problem, and allows the teacher to do more explaining in cases where it is necessary to get the student started on his activity.

There is one point in particular that should be emphasized (the reader will note that it was emphasized in the exercise)—the whole exercise is based on analogy and assumptions. The assumptions are valid to a certain extent; the important thing is that they *are* assumptions. The student must be cognizant of this.

The steel balls represent alpha particles—an analogy. The steel balls have magnetic properties and the alpha particles possess an electric charge—another analogy if the magnetic properties are used to simulate the charge. The assumption that must be made here is that the magnetic properties of the steel balls will cause them to behave in some manner similar to the behavior of the alpha particles.

The neutrons are likened to the glass marbles. The analogy is obvious: the nonmagnetic character of the marbles simulates the absence of charge on the neutron.

Electrons in the orbits of the uranium atom are represented by the magnets, which are lined up on each side of the paper trough with their poles opposed. Again, the magnetic fields of the magnets are likened to the electric fields due to the electrons.

When the glass marbles and steel balls are rolled down the trough the steel balls will be slowed, while the marbles will be unaffected. The magnetic effects observed can be likened to the electric effects which occur in the uranium atom. The interaction of the electric fields of the alpha particle and the electrons is compared with the interaction of the magnets and the steel balls, while the absence of magnetic effect on the glass marbles illustrates the absence of electrical effects on the uncharged neutron.

The assumption is made that the steel balls, and the glass marbles, will behave in a magnetic field in a fashion somewhat similar to the behavior of a charged particle and a neutron, respectively, in the electric field of the uranium atom. This assumes some degree of similarity between an electric field and a magnetic field.

The uranium atom has a large number of electrons circling the nucleus. In order to accomplish fission of the uranium nucleus the particle used for a projectile must penetrate this cloud of electrons and score a direct hit on the nucleus. Because of the interaction of charges, this is difficult to accomplish with charged particles. The neutron, on the other hand, can pass through the electric field without being deviated from its path, or slowed, since it has no charge. The nucleus of the uranium atom, of course, has a charge too. The neutron, being neutral, can contact the nucleus without suffering deflection, or slowing.

The exercise attempts, in some degree, to illustrate these concepts and, at the same time, do it in a way that will furnish the student with a creative activity.

U^{235}—One in a Hundred and Seventy

In about every one hundred and seventy atoms of uranium there occurs one having an atomic weight of 235. The rest are almost entirely U^{238}; U^{234} occurs very infrequently.

The mass spectrograph is a device which is used to separate U^{235} from U^{238}; the former is the isotope which will undergo the fission process.

A creative exercise can be worked out that will illustrate certain of the concepts involved in the use of the mass spectrograph for this purpose. The exercise need not be presented in full since it can follow much the same organization as the one just given.

The problem is to devise and execute an exercise that will illustrate the use of the mass spectrograph in separating the isotopes of uranium. (This is perhaps a good time to remind the reader that the mass spectrograph is not the only, or even the main, means for doing this.)

A large Alnico magnet is used to represent the mass spectrograph; a war surplus magnetron magnet does the job beautifully. The charged uranium atoms (ions) are represented by steel balls of two sizes, the larger for U^{238} and the smaller for U^{235}. When the balls are dropped from the height of a table top, in such a way as to fall slightly to one side of the space of strongest field, the balls will describe an arc through the magnet. The angle at which the steel balls emerge on the opposite side of the magnet will depend on the mass of the ball, assuming constant velocity. It is well to provide a wooden jig with a hole through which to drop the balls, since their desired action in the field depends on their falling into a space of small dimensions which is quite critical and somewhat hard to locate. Once it is found, a plumb bob (of brass or lead) can be dropped from the center of the hole to near the magnet, and measurements taken for future use.

An alternative exercise to illustrate the same concepts can be worked out in somewhat similar fashion. Because it is simpler, and does not require such a powerful magnet, it may be preferred by some.

The main difference between the exercise above and this one is that while the other is carried on in a vertical position, this one is done horizontally. A magnet is placed on a smooth, level, surface and steel balls of two sizes are caused to roll past its poles (or pole, if it is a bar magnet). The balls are given the same velocity by starting them at the same point on an inclined plane, and the velocity is adjusted according to the strength of the magnet.

It is evident that the heavier balls will be deflected from their path by a smaller amount than will the lighter balls. Boxes, or "stalls" can even be provided into which the balls will roll, one for the larger, another for the smaller. These would simulate collecting devices for the uranium atoms.

The second exercise will probably not catch the interest of the students to the degree that the first will, but it is easier to make "work" and does not require the large, powerful, magnet, which may not be readily available.

In order that the reader may rapidly review the operation of the mass spectrograph, and better see, perhaps, the purposes of the exercises just discussed, it will be considered briefly. The mass spectrograph was developed originally to study positive rays and isotopes. Three men are perhaps most responsible for its early design—Sir J. J. Thomson and F. W. Aston in England, and A. J. Dempster in this country. Investigations have been carried on since about 1905, with Aston's contributions, probably the most significant, occurring about 1919.

One may object to the name "mass spectrograph" when applied to a device used to separate isotopes of an element. The name carries over from the first use of the apparatus when the isotopes were identified by the trace left by their ions (positive rays) on a photographic plate, yielding a graphical record of their relative masses.

For purposes of explanation we might examine what is essentially the Dempster apparatus for studying positive rays, or positive ions. He produced the ions by vaporizing them from a filament coated with a suitable salt, or compound, of the desired element. In some cases he vaporized a metal directly. The atoms were ionized (charged) by bombardment with electrons from a second filament. The positively charged ions were then attracted toward a cathode (negatively charged plate) in which there was a small slit. Those ions that passed through the narrow slit entered a magnetic field which was perpendicular to the path of the ions. They were thus made to describe an

arc, the lighter isotopes following an arc of smaller radius than the heavy isotopes, and to impinge on a photographic plate.

The reader will recall that a *moving* charged particle in a magnetic field will be deflected in a direction perpendicular to its direction of motion and to the direction of the magnetic field.

The assumptions necessary here are readily discernible. The most important assumption is that the steel balls will behave in a magnetic field in a way compatible to action of a charged particle in motion in a magnetic field. To strengthen the assumption, remember that the charged particle in motion, as well as the steel ball, has magnetic properties. The charge in motion constitutes an electric current, and as such is encircled by a magnetic field.

What Is This "Chain Reaction"?

The production of large quantities of energy by a chain reaction, and the manner in which it proceeds can be illustrated by a simple exercise. This exercise is not as good as the famous mouse trap demonstration devised by Dr. Sutton, but neither does it require two hundred mouse traps. It is not difficult to do and is well within the capabilities of junior high school children.

Use an ordinary domino standing on end to represent an atom of U^{235}. A domino lying flat indicates that the uranium has been converted into atoms of barium and krypton, or into atoms of strontium and xenon. The change, of course, from uranium to the other two atoms is simulated by the falling domino.

The fission of the uranium is accompanied by radiation of beta particles, gamma rays, and other radiation. Also, and very important, by the release of two or more neutrons from each atom of uranium. These radiations are simulated by the falling domino.

The dominoes are arranged in a triangular space, standing on end, in such a way that if the domino at the apex of the triangle is caused to tip into the two ahead of it, they will fall into the next three or four, and so on.

Certain of the analogies were mentioned above. There are others that can be brought in, too, although they are not strong. The radiations and the release of energy can be compared to the sound, and to the energy of the falling domino, respectively. Sound is a radiation, although of an entirely different type.

The concepts of critical size and the necessity for using neutrons with thermal velocities will have to remain abstract, if they are considered.

Some of the deficiencies of this exercise should be noted, too. In the first place, to arrange the dominoes so that as each one falls it

will "release two neturons," or cause two more to fall, is impossible. The number that fall, or "undergo fission," will increase by not more than two with each row of dominoes. This is not, of course, strictly analogous to the real chain reaction, where each time a uranium atom splits, it releases at least two neutrons which go on to split two more, these neutrons split four more, then eight, then sixteen, and so on.

In the chain reaction which neutron will cause the fission of a given uranium atom is entirely a matter of chance. The neutrons move entirely at random; they may pass through an atom without causing fission if they are moving too fast. In the chain reaction there is no particular pattern, or organization, to the process of fission, it is of a random nature. In the exercise, of course, it is easily predicted which falling domino (neutron) will cause a certain other domino to fall (uranium atom to split).

The deficiencies of the analogy should be made clear to the student.

The Chain Reaction Controlled

By modifying the exercise dealing with the chain reaction just a little it is possible to illustrate some of the additional concepts of the atomic pile, or nuclear reactor.

The chain reaction in a reactor proceeds at a speed that can be readily controlled by inserting cadmium rods into the pile. Cadmium is a good absorber of neutrons, and prevents them from causing fission in the uranium. To slow the action down the rods are pushed in, to speed it up, they are pulled out.

When the dominoes are arranged to illustrate a chain reaction (uncontrolled) it is only necessary to insert a meter stick on edge between the rows of dominoes to control it.

The concept of the production of plutonium, a fissile material, from U^{238}, which is nonfissile, will probably have to remain an abstraction.

What Does a Geiger Counter Count, and Why?

The Geiger counter is a detection device used to indicate the presence of certain types of radiation. Its main feature is the ionization chamber which contains a gas at low pressure. This chamber has a "window" of thin material through which even the less energetic radiations or particles can pass. Once inside the chamber the particles (or radiation) ionize the gas. The ionized gas is made to conduct a current by means of a high potential across the chamber; the effect of this small current is impressed on the grid of a vacuum tube, amplified, and emerges as sound at the speaker.

Each separate click of the counter indicates that an atom has disintegrated radioactively, and has radiated energy.

In this exercise an ordinary radio receiver is used to simulate the Geiger counter. An electrostatic generator simulates the radioactive material; it must be of the usual variety having condensers which must be charged to a certain potential before a spark discharge occurs.

When the spark discharge occurs, it radiates electromagnetic waves, the same type (but of much longer wavelength) as gamma rays from a radioactive material. The radiations from the discharge will embrace the radio-frequency range and will be picked up by the radio, causing a sound in the speaker resembling the "click" in the Geiger counter.

The analogies here are obvious; some have been mentioned. There is considerable similarity between the radio and the Geiger counter. The radiation is picked up, on the antenna by the radio, and by the ionization chamber in the case of the counter. Then somewhat the same processes occur in both radio and counter before it emerges as sound at the speakers. That both react to electromagnetic radiation has been mentioned.

The emission of radiation by a radioactive material proceeds erratically, whereas the spark discharges from the static generator will occur at time intervals fairly evenly spaced. The analogy breaks down here, but probably not seriously.

In a Nutshell

Here, possibly, is a partial solution to the problem of activities (other than reading) for the student in the field of nucleonics. Let the student do some of his own thinking in setting up an activity to illustrate a concept. The experience may be as valuable to him as a knowledge of the concept.

Remember that the activities are based on analogy and simulation. Be certain that assumptions made are recognized as such by the students, and don't apologize for them. The whole of science developed from assumptions. They are the stuff on which hypotheses and theories are built.

The teacher can, without a doubt, improve the exercises suggested here, and add to their number. "Ideas are ammunition." Perhaps this article has provided some ammunition for use in the science laboratory. By all means let the student think for himself. But reasoning by analogy must be done with *very* great care. It often turns out to be fallacious.

OUTLINE OF THE HISTORY OF ARITHMETIC

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I. *The Period before 1600*

A. *The Ancient Period* (3100 B.C.–1 B.C.). Early instruction probably entirely oral; systems of numeration varied with languages.

1. *Babylonian* (2000 B.C.–1 B.C.): records on tablets in cuneiform writing; beginnings of number system; positional notation, sexagesimal superimposed on original decimal system; numerical tables for multiplication, inversions, squares, square roots, powers of a number, Pythagorean numbers; simple and compound interest; special symbol for zero (400 B.C.); some negative numbers; applications in astronomy and commerce. Mathematics more highly developed than that of other Ancients.
2. *Egyptian* (2900 B.C.–1 B.C.): records in form of picture writing, Moscow papyrus (1850 B.C.), Rhind papyrus (1650 B.C.); decimal system without positional notation with special sign for each higher decimal unit, writing of large numbers well established; unit fractions; applications to practical problems, great pyramid (2900 B.C.), obelisks and timepieces (1850 B.C.), astronomy; no evidence of knowledge of even a particular case of the Pythagorean theorem.
3. *Chinese* (Probably contemporaneous with Babylon and Egypt): no pre-Christian records extant; early records in Ten Classics of period about 1112 B.C. to 256 B.C., written on paper about 618 A.D. to 907 A.D.; earliest number system was decimal with special symbols for higher units but later numbers had position system with higher units represented by a repetition of the lower units; special symbol for zero; sexagesimal decimal system used in computations of the calendar; magic squares; source of many of our present numerical problems. Approximately same mathematical development as Egyptians.
4. *Mayas* (500 B.C.–600 A.D.): records in a kind of picture writing; numbers written in head form or as combinations of dots and bars; vigesimal system of numbers with positional notation; special sign for zero; developed writing of large numbers; no fractions, but did long numerical computations of multiplication and division; applications to calendar.

5. *Hindus* (1500 B.C.–600 A.D.): no pre-Christian records; special cases of Pythagorean theorem, approximations of irrationals with unit fractions (500 B.C.); decimal system with special signs for higher units (300 B.C.); positional notation and zero symbol introduced at an unknown date; definitely ***first to develop our present adequate number system*** capable of miraculous powers of calculation.

B. *The Greek and Roman Period* (600 B.C.–600 A.D.). System of numeration not adequate and except for Archimedes did not represent moderately large numbers concisely.

1. *Thales* (624 B.C.–547 B.C.): first Greek mathematician known by name; number represented by first letter of its name.
2. *Pythagoras* (569 B.C.–500 B.C.): arithmetic considered geometrically, triangular numbers, square numbers, pentagonal numbers; mystic properties of numbers, masculine or feminine; beginnings of theory of numbers as constrasted with computation; tried to derive all mathematics from numbers; knew relations such as

$$1+3+5+\cdots+(2n-1)=n^2;$$

realized irrationals existed but did not accept into number system; approximated the square root of two; applications to music and astronomy, but investigation of numbers independent of geometrical representation all but ceased.
3. *Around 500* B.C.: more compact system of numeration than that of Thales was introduced, first nine letters for first nine numbers, next nine letters for tens from 10 to 90, etc.
4. *Eudoxus* (408 B.C.–355 B.C.): theory of proportions to eliminate the arithmetic theory of Pythagoras which applied only to commensurable quantities; applied to astronomy in attempt to explain the motion of the planets (around the earth).
5. *Euclid* (365 B.C.–275 B.C.): emphasized ancient arithmetic; many results in number theory, proved number of primes infinite, gave basic theorems on arithmetic divisibility; presented Eudoxus' geometric theory of irrationals; proved results in excellent logical manner; gave no approximations of irrational numbers.
6. *Archimedes* (287 B.C.–212 B.C.): just missed place system of numeration with method of writing large numbers; approximated π between 3.141697 and 3.141495; approximated irrational numbers; applications to areas, volumes,

hydrostatics, music, astronomy; great computational ability; greatest Greek mathematician.

7. *Eratosthenes* (276 B.C.–195 B.C.): number theory, gave method for finding prime numbers.
8. *Hypsicles* (180 B.C.): extensive study of progressions.
9. *Heron* (75 A.D.): approximated square roots of non-square numbers (like Babylonians); obtained cube root of non-cube number; many practical applications to areas, volumes, surveying, computation, mechanics; used typical Egyptian unit fractions; used a zero symbol to mean "nothing"; used a blend of Greek and Oriental methods.
10. *Diophantus* (75 A.D.): thirteen books (six extant) on arithmetic relating more to algebra than to arithmetic; accepted fractions as numbers instead of an aliquot part; more Oriental than Heron.
11. *Nicomachus* (100 A.D.): most complete exposition extant of Pythagorean arithmetic; emphasized mystical aspects, influenced medieval arithmetic through Boethius.
12. *Boethius* (475–554, Italian): his text served as standard in church schools into seventeenth century; made ideas of Nicomachus known in western Europe with emphasis on commercial and mystic aspects; significance of mathematics as a deductive system omitted. (The Romans gave us the Roman numeral system, probably improved the abacus, permanently affected our system of weights and measures but otherwise influenced mathematics very little.)

C. *The Hindu, Arabic, Persian Period* (600–1200). Early part of period saw introduction of zero symbol and perfection of the system of place value which was known to Arabic scholars early in the ninth century; many applications to mensuration and world affairs; introduced interest, partnership, gain in trade; later part of period produced a number of writers on arithmetic; oldest European manuscript containing Hindu-Arabic numerals written in Spain in 976.

1. *Al-Khowarizmi* (825): extensive use of Hindu numerals in his text on arithmetic; no Arabic text extant, only a Latin translation; exhibited a negative number without explicitly rejecting it.
2. *Abu'l Wefa* (940–998): wrote (990–998) an extended business arithmetic but omitted calculation of interest.
3. *Al-Karkhi* (1010): wrote arithmetic giving some shortcuts in multiplication; mensuration of surfaces and solids; used Greek methods.

4. *Adelard* (11th Cent): translated Euclid and Al-Khowarizmi's arithmetic into Latin. (Al-Khowarizmi's arithmetic also translated in twelfth century by an Englishman, Robert of Chester, and by a Spaniard, John of Luna.)
5. *Rabbi Ben Esra* (1140): treatise on arithmetic preserved in a Hebrew manuscript, his fame sung by Robert Browning.

D. *The Period 1200 to 1600.* Italian interest in commerce, navigation and discovery aided increased interest in arithmetic.

1. *Leonardo of Pisa* (1175–1250, Italian): gave extensive treatment of arithmetic to help make Hindu-Arabic arithmetic popular in Christian Europe (1202); interpreted a negative number as a loss; practical problems on business, showing Hindu, Arabic, Greek, Roman and Chinese influences.
2. *Sacrobosco* (died 1256, English): wrote a small book on Hindu arithmetic which was read in France and Italy for several centuries; more popular (but less thorough) than Leonardo's because much shorter.
3. Earliest French manuscript containing Hindu numerals dates from 1275; bankers of Florence were forced (1299) to use Roman numerals and forbidden to use Hindu numerals.
4. First (1478) printed arithmetic (written in Italian) appeared anonymously at Treviso, Italy.
5. Caxton Press published (1481) in England first book in English containing some arithmetic (not a text in arithmetic).
6. First arithmetic printed (1482) in Germany appeared in Bamberg; emphasized commercial aspects.
7. *Beldamandi* (died 1428, Italian): his treatise printed (1483) at Padua, Italy was first Latin book printed on the new numerals; merchants systematically used them after 1494.
8. In the early 16th century many commercial arithmetics appeared in Italy and, mostly a little later, similar ones appeared in Germany; Paciuolo wrote (1494) a comprehensive arithmetic and first treatise on bookkeeping.
9. *Bishop Tonstall* (1474–1559, English): printed (about 1522) first arithmetic in England; first printed works in English explaining the Hindu numerals came out in 1537 and 1539.
10. *Recorde* (1510–1558, English): published (1540) an arithmetic which popularized our system of numerals and com-

putation; emphasized commercial aspects, had 27 editions to 1699.

11. *Cardano* (1501–1576, Italian): made (1545) formal use of negative and complex numbers without completely accepting them as numbers.
12. *Juan Diez* (Spanish): published (1556) in Mexico first mathematical work of the New World, contained tables for buying gold and silver, arithmetic for counting-house apprentices and some algebra.
13. *Stevin* (1548–1620, Dutch): published (1582) first compound interest tables; published (1585) first systematic explanation of decimal fractions, *second step in developing tremendous powers of calculation with Hindu-Arabic number system.*

II. *The Period after 1600.*

A. *The Seventeenth Century.* A large number of texts published in Holland in early seventeenth century because of great mercantile activity from 1575 to 1650. These texts greatly influenced those of England. The continental texts were usually more scientific than those in England. About as many texts avoided decimal fractions as used them. Beginnings of modern theory of numbers made in 1630.

1. *Napier* (1550–1617, Scot): invented (1614) logarithms (*third step in aid to calculations*); decimal point appeared (1616) in print in the English translation of Napier's work.
2. *Burgi* (1552–1632, Swiss): developed (1620) logarithms independently of Napier.
3. *Pedro de Paz* (Spanish): published (1623) first arithmetic in America at Mexico City.
4. *Kepler* (1571–1630, German): simplified computations and published (1624) a volume of logarithms.
5. *Oughtred* (1574–1660, English): introduced (about 1622) slide rule, published (1647) text on arithmetic and algebra.
6. *Fermat* (1601–1665, French): gave (1630) many results beginning modern theory of numbers; developed infinite descent method of proof; proved (1654) that every prime of the form $8n+1$ is representable in the form

$$x^2+2y^2 \ (x,\ y \text{ integers}),$$

which began the arithmetic theory of quadratic forms; stated (Fermat Last Theorem) $x^n+y^n=z^n$ impossible in

integers for n greater than two; stated if n is a positive integer not divisible by a positive prime p, then $n^{p-1}-1$ is divisible by p.

B. *The Eighteenth Century.* Decimal fractions became a regular part of arithmetic, interest increased in the theory of numbers.

1. *Bradford* (1663–1752, English): gave (1705) first extended treatment of arithmetic in America, text had seven editions up to 1738; first arithmetic published (1719) as a separate text in the American Colonies was a reprint of Hodder's English work.
2. *Greenwood* (1702–1745, American): first (1729) American to write an arithmetic, text included full modern treatment of decimal fractions, more advanced treatment than Hodder's, omitted obsolete material.
3. *Pike* (1743–1819, American): wrote (1788) popular text giving many applications and some algebra.
4. *Euler* (1707–1783, Swiss): initiated study of quadratic forms in the theory of numbers.
5. *Continental Congress*: adopted (1785) decimal coinage in the United States.
6. *Lagrange* (1736–1813, Italian-French): worked with quadratic forms and number theory.
7. *Legendre* (1752–1833, French): made additional study of quadratic forms and number theory.

C. *The Nineteenth and Twentieth Centuries.* Gauss (1777–1855, German) was the first to systematically deal with quadratic forms and he systematized (1801) the theory of numbers and firmly established it as a separate branch of mathematics. The subject has grown rapidly since and there has followed a widely generalized concept of number and extensions of the number system by means of algebra. Liouville (1809–1882, French) broadened the nature of real numbers when he proved (1844) the existence of transcendentals. The transcendence of e was proved (1873) by Hermite (1822–1905, French) and Lindemann (1852–1939, German) showed π is transcendental in 1882. A general basis for extensions of the number system dictated by an abstract deductive science was first given (1834–1845) by Peacock (1791–1858, English). This idea, effectively expounded (1867) by Hankel (1814–1899, German), led Dedekind (1831–1916, German) to create (1879) his theory of the real number system. Other developments of the real number system were given in 1860 by Weier-

strass (1815–1897, German) and in 1871 by Cantor (1845–1918, German). Since this forms a part of the history of algebra and analysis, additional details are omitted from this outline.

MODELS OF SOLIDS OF KNOWN PARALLEL CROSS SECTION

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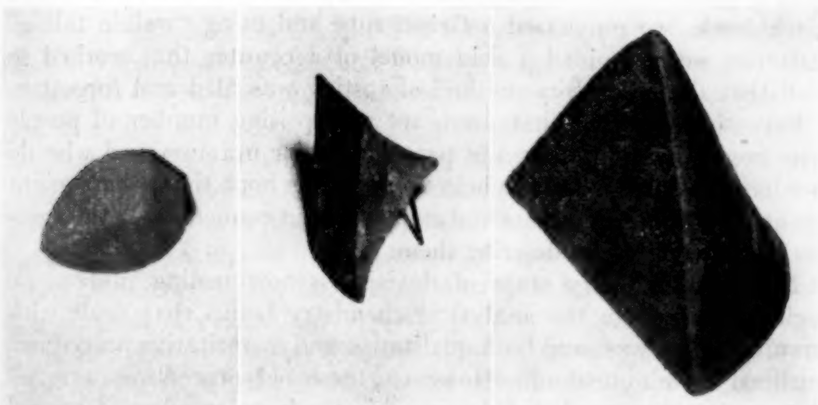
Hawthorne in the June 1951 issue of SCHOOL SCIENCE AND MATHEMATICS (pp. 470–471) explained the use of doctor's applicators in building models of solids of known parallel cross section intended to aid the student of calculus who is confronted with a description of such a solid and asked to find its volume.

Models with a known parallel cross section can also be made from modeling clay. The pictures below show a few such models.



Illustrations of problems from *Elements of the Differential and Integral Calculus* by Granville, Smith, Langley.

In finding the volume of such solids by means of calculus, the student must find the area of the known cross section. After the model was made a two dimensional coordinate system was drawn on a piece of cardboard. The clay model was placed on the coordinate system in such a way as to fulfill the conditions of the given problem. A third coordinate was added to our system by placing a wooden meat skewer perpendicular to the origin of the two dimensional system. It was now quite easy to see the relation between the curve of the base of the solid (whose equation is given in the problem) and the dimensions of the known cross section.

IDENTIFICATION OF URANIUM ORE SIMPLIFIED BY COMBINED CHEMICAL-PHYSICAL TEST

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A few years ago, when Geiger counters were both scarce and expensive, we conducted a series of carefully controlled experiments with the idea of developing a reliable chemical process for identifying uranium ores. In order to be useful to the average prospector, rock hunter or curious member of some chemistry class, the process would have to be non-technical, inexpensive and designed to give quick results. After many trials, some of which led to chemical blind alleys, and at a point where the procedure was getting longer instead of shorter, we stumbled upon the shortcut that we were seeking, quite by accident.

A few months after the testing process had been standardized so that it gave reliable results with ordinary samples of carnotite and pitchblende, we purchased a Geiger tube and using "walkie talkie" batteries we assembled a field model of a counter that worked so well that the laboratory method of testing was filed and forgotten. I have since realized that there are a surprising number of people who are actively interested in prospecting for uranium and who do not have Geiger counters to help them. In the hope that others might profit from our experiments and experiences in connection with uranium ores, I will briefly describe them.

In the preliminary steps of devising a new testing process we logically turned to the analytical chemistry books that dealt with uranium. Here we found both qualitative and quantitative procedures outlined in minute detail. However, these old procedures were all long and complicated, besides requiring a large number of special testing solutions, In our search for a shorter and less specialized process, we finally selected a set of reactions given in *Smith's College Chemistry* as most nearly fitting our requirements. In these reactions we found that when uraninite was treated with 1:1 sulfuric acid the uranium went into solution in the form of uranyl sulfate (UO_2SO_4), along with the sulfates of iron, manganese, copper and other metals that may have been present in the sample.

When this acid solution was neutralized with sodium carbonate, we learned that sodium uranyl carbonate $Na_4UO_2(CO_3)_3$ stayed in solution, while the iron, copper and other metals precipitated as carbonates and hydroxides. The $Na_4UO_2(CO_3)_3$ could then be converted back to UO_2SO_4 by acidifying this filtrate with sulfuric acid and boiling.

The reconverted UO_2SO_4 solution was then neutralized with sodium hydroxide and an excess added. This precipitated sodium diuranate ($Na_2U_2O_7$) which has an orange color.

Since these reactions used ordinary laboratory reagents, required no special solutions and yielded an orange precipitate that would be easy to identify, we began to test the possibilities of this process. A weak solution of uranyl acetate was first tried and the orange sodium diuranate precipitate appeared just as predicted. Then samples of ground granite and ground basalt were both enriched with a few milligrams of uranyl acetate and tested. These samples gave heavy carbonate precipitates but gave the distinct orange test in the last step.

Finally the cooperating students were given unknown samples of ground granite and basalt, some of which did not contain uranium. By using the above reactions with slight modifications the uranium bearing samples were identified with perfect accuracy. As soon as the procedure was adjusted to give dependable results with the prepared uranium samples, a ground sample of carnotite was tested. We were so sure that our process was reliable that it was quite a shock when no orange sodium diuranate appeared in the last step. It was possibly a poor extraction, we reasoned, so a second sample was boiled in the 1:1 sulfuric acid for a longer time but gave no result. A third sample was boiled in concentrated sulfuric acid in the hood, until the white fumes of sulfur trioxide appeared but it gave no test. A fourth sample was fused in sodium carbonate, then neutralized and boiled in 1:1 acid and still no uranium was found. By this time it was quite evident that the chemical process had failed rather than the method of extraction.

At this point we began to doubt the wisdom of spending any more time trying to shorten a process that insisted on growing longer. I remembered that the uranium acetate had fluoresced on another occasion, when radiated with ultraviolet light. On the remote chance that uranium sulfate and other uranium compounds might fluoresce and allow us to trace the lost uranium in the carnotite trials we decided to check the steps with the mineral light. The student who had run the carnotite trials had saved a large number of his filter papers with the percipitates upon them. Several of these precipitates fluoresced with a bright yellow glow.

This was not especially enlightening but it did encourage us to run another trial so that all the chemical steps might be checked with the mineral light.

A carnotite sample was fused in sodium carbonate then neutralized with 1:1 sulfuric acid and boiled a few minutes in excess acid. When the sample was radiated with ultraviolet light both the residue and

the acid solution fluoresced with a greenish yellow glow and we suddenly realized that this combined chemical-physical test was just what we were looking for to give quick and reliable results. After stumbling onto this shortcut we never bothered to determine the cause for our lost uranium in the original process.

Neither carnotite nor pitchblende, the most common ores of uranium, will fluoresce in ultraviolet light but as soon as their uranium content is converted into sulfate salts, they glow with a yellow fluorescence. A reliable test can be made by gently boiling 5–10 grams of ground sample for about fifteen minutes in enough 1:1 sulfuric acid to prevent it from spattering, then checking it with the ultraviolet light. Of course, all potential uranium samples should be tested with the light before they are treated with acid to insure that they do not already contain some mineral that fluoresces yellow. Both the residue and the acid solution from a sample should be tested with the ultraviolet light. A yellow or greenish yellow fluorescence in either one of them is worth getting excited about. Thorium gave almost the same fluorescence as uranium when the test was applied to monazite sand but this metal is very scarce compared to uranium so that the chance of a deception from thorium is very small.

If one prefers, the powdered sample may be fused with equal parts of sodium carbonate then dissolved in an excess of sulfuric acid and heated to the boiling point. This method of testing usually requires more time but it has the advantage of using weaker acid and it eliminates the boiling process in which the strong acid is apt to spatter.

The reader may have one question in mind that has not been answered at this point, namely, "What should I do besides being excited if a suspected uranium sample gives the yellow fluorescence?" In answering this question let me point out that this chemical-physical test for uranium is not considered to be equal to the Geiger counter but has been offered as an inexpensive substitute for this costly instrument. Hence I would make immediate plans to have the samples double checked by some reliable person or organization that has a Geiger counter. If the sample is radioactive, advise the Atomic Energy Commission without delay.

Just one more word from the voice of experience in closing. The large rock pile that accumulates from the samples that give negative results will make a nice rock garden. Instead of wishing you luck I will say "May all of your samples fluoresce with a yellow glow!"

Glassware washer for chemical laboratories will thoroughly clean all glass utensils from pipettes to flasks in a relatively short period. Inside the enameled box is a vertical wheel which holds baskets for the glassware on its rim. Revolving slowly by electric power it dunks and redunks the utensils.

WE TEACH FOR TOMORROW

KENNETH V. LOTTICK
Willamette University, Salem, Oregon
AND
MISS BETTYELLA LEFILES*
Student Teacher, 1949–1950

At a recent Future Teachers of Oregon meeting, Cecil Posey, Executive Secretary of the Oregon Education Association, made a striking statement—originating the title of this report: "We must prepare our students today to live in the world of 2000." Mr. Posey insisted on today's students becoming familiar with the new forces recently released in the world. This, of course, points especially to the need for instruction in the nature of the atom and its possibilities for energy development.

Assistant Superintendent Harry Johnson, of the Salem City Schools, heartily in favor of this idea, had already encouraged the local high schools to undertake a study of atomic energy. Mr. Johnson reported some disagreement, as he suggests in the *Curriculum Bulletin*, but this, seemingly, was not considered a good reason for not embarking in the new direction. He says:

> . . . We were somewhat taken aback when friends intimated that they thought it was rather far-fetched that we should bring in the subject of the atom for general school study in junior and senior high. The reason for objecting was that the subject is way over the heads of both teachers and pupils, and furthermore there is danger of crowding out other important learnings.
>
> Perhaps we are moved by the same attitudes we took toward aviation education, air-age or global geography, or the other extensions of knowledge. Isn't it a fact that no matter how we tend to hold back and cling fondly to our own backgrounds and concepts, change will nevertheless take place? The atomic age is with us; already our vocabulary is becoming enriched with new words: electrons, neutrons, protons, isotopes, chain reactions, atomic piles!

An experience in teaching such a unit on the junior high school level is the subject of this paper. While it is not maintained or even suggested that the methods or coverage used represent the ideal or are considered a model for imitation in other schools, nevertheless the success which attended the original project does mark it as worthwhile pioneering and, a step in the right direction.

Thus, in line with this idea, on April 10, 1950, which, curiously, was exactly ten years after Hitler's blitzkrieg of Scandinavia demonstrated the grave probability of another world war, Miss Bettyella LeFiles, a student teacher from Willamette University's department

* Miss LeFiles is now serving as science instructor, Glide (Oregon) High School.

of education, began the introduction of her unit on "Atomic Energy and Its Potentialities" in a ninth grade science section at the J. L. Parrish Junior High School, Salem, Oregon.

High time, many of you will say, but then Education (with a capital E) moves slowly, as Mr. Johnson suggested. Moreover, we venture to think that Miss LeFiles' unit, for ninth graders, mind you, was not far from the vanguard in the attempt to prepare today's adolescents for tomorrow's world.

Indeed, tomorrow's world burst suddenly upon us again last June 25. Thus, it would be fatuous as well as criminal to suppose that we can ever go back to the old naive normalcy of 1940. In fact, present events suggest that much of the five years between Almagordo and the rude awakening at Seoul was wasted. It behooves us to work swiftly to try to make up this lost time.

The "Atomic Energy Unit" was introduced with the permission of Miss LeFiles' master teacher, Miss Constance Weinman, and with the blessing of Principal Carl P. Aschenbrenner, who was eager to attempt the bridging of this gap and to see just how much ninth graders could learn about the area that had ninety-nine percent of the adults puzzled.

And, on the whole, the results were pleasing. The enthusiasm shown by the students was encouraging, for some who had shown little interest in class now began to perk up and do much better work; on the other hand, however, some of the "better" students did not show the enthusiasm expected. Could the explanation be that they, like some of their elders, feared to jeopardize their previous ascendency by exposing themselves to an entirely new area of thought? Most students, notwithstanding, emerged from the experiment with a basic understanding of the atom and the potentialities of atomic energy. Moreover, they were somewhat sobered by a realization that, without co-operation, these potentialities, if not indeed a source for world downfall, would be wasted. However, a full evaluation of such learning cannot be made at this time; what these students do in advanced courses and how their new knowledge colors their social judgment in later situations is, of course, the real test.

On the basis of her experience as teacher, Miss LeFiles feels that approximately twenty-five class periods are necessary for the handling of the unit. Interruptions or the encroachment of other school activities may even call for an enlargement of this number of days. How the experimenter divided this time will be shown in the schedule which follows this general discussion of the unit, her sources, and methods.

Miss LeFiles' class used the following printed materials (although the students' reading was greatly enlarged by newspaper, pamphlet,

and magazine articles and sources that they were able to discover in independent study):

1. *How Dagwood Splits the Atom.* King Features Syndicate, New York. This proved a good introduction, for it created an interest and yet served as an incentive for the securing of other worthwhile information.
2. *Atomic Energy—Double Edged Sword of Science.* R. Will Burnett. Charles E. Merrill Co., Berkeley, Calif. This proved to be the most popular piece of reference material. The experimenter felt that "it would be fine if each student were able to have a copy of this."
3. "Atoms, Energy, Electrons." Reprints from 1950 *Compton's Pictured Encyclopedia.* F. E. Compton & Co., Chicago. Students found this information was in a form that they could readily understand.
4. *Adventures Inside the Atom.* General Electric Corporation, Schenectady, N. Y.
5. *Atomic Energy in Our Time.* General Electric Corporation.
6. *Operation Atomic Vision.*
7. *The World Within the Atom.* Westinghouse Corporation, Pittsburgh, Pa., Students found this source not as helpful as the other materials mentioned above.
8. *David and the Atom Slingshot.* U. S. Atomic Energy Commission, Washington, D. C. Miss LeFiles reports that this source contained very little useful information for her project and that even the student who had made a special report on the cyclotron had not found much use for it.

Several recent issues (1949–1950) of *Life.* Especially May 16, 1949.

The following films and filmstrips also were used in connection with the Atomic Energy project:

1. "Atomic Power," March of Time. 19 min. Re-enactment of the events leading to the successful manufacture of the atomic bomb. Also suggests problems brought on by the existence of the bomb.
2. "One World or None," Film Publishers, Inc. 10 min. Develops the concept that the atomic bomb demands world understanding and co-operation to prevent world destruction. (Many of the student attitudes resulting from the study may be traced to the power of this film.)
3. "Atomic Energy," Encyclopedia Britannica Films, 10 min. Portrays and explains by means of animation concepts basic to an understanding of what atomic energy is and how atomic energy is released. A helpful manuscript is supplied by the manufacturers of this film.
4. "Atomic Energy," a filmstrip. The advantage of this filmstrip is that you can go slowly and talk about each development as the frame is thrown on the screen. Although the films were shown several times it was found that most films "went too fast" for the majority of the class to comprehend.
5. "Principles of Electricity," an animated film.
6. "The Atom," a filmstrip.

[These films and filmstrips were obtained from the State Department of Visual Instruction, Corvallis, and from the City Schools Audio-Visual Aids Center, Ralph E. Tavenner, Supervisor.]

Special devices, school trips, or demonstrations which aided in developing an understanding of atomic energy

1. Clay models. Made with lollipop sticks to illustrate the atom's structure. (Tinkertoys also can be used for this.)
2. Drawings of the atomic bomb and the hydrogen bomb from various sources which were enlarged and placed on bulletin boards.
3. Maps drawn to indicate the locations of uranium deposits. Both in United States and the world.

4. Notebooks and scrapbooks containing pictures, student made illustrations, observations, newspaper clippings, etc. (Each student made one as an individual project.)

5. A field trip was made to Willamette University's science laboratory to see a Geiger counter and hear it explained by Professor Robert L. Purbrick, who worked on atomic research for the government at the University of Wisconsin during World War II. Even when the novelty of this trip is discounted, student interest in the event was considered high.

6. Charts of the elements with periodic weights, etc.

Topics developed by the use of special reports, panels, or roundtable discussions

1. About the biographies of certain scientists and their special contributions to the understanding of atomic energy:
   a. Glen Seabork
   b. J. J. Thompson
   c. Fermi
   d. J. Robert Oppenheimer
   e. Rutherford
   f. Madame Curie
   g. Nils Bohr
   h. Lise Meitner
   i. Chadwick
   j. Earnest Lawrence
   k. Carl David Anderson
2. By general reports by individual students and/or discussions on:
   a. Atomic pile
   b. "A" bomb
   c. Plutonium
   d. Separation of Uranium
   e. Geiger counters
   f. Cyclotrons
   g. Atom smashing
   h. Electron tubes
   i. "Atomic Energy in the Future"
   j. "What We Are Doing with Atomic Energy"
   k. "Atomic Energy and Medicine."

Time schedule, log, and syllabus

Apr. 10. Read "Dagwood Splits the Atom." Write answers to the questions that were placed on the blackboard. (See the following section for a list of the questions used.)

Apr. 11. Re-read "Dagwood Splits the Atom." After a discussion of the answers to the questions presented the day before, the following new questions were brought up, partly by students and partly by the teacher:
1. What are some examples of molecules breaking up into atoms?
2. How large is an electron?
3. What are some substances that have very large molecules?
4. What are some radioactive elements?
   Are they naturally radioactive?
   Will they ever stop being radioactive?

Apr. 12. Further discussion of questions mentioned above and additional ones brought up by the students. This list was then put into the notebooks; the students worked on them during the unit and handed them in at various times during the course.

New questions brought up by students:

1. What is the "atomic number"? How many atomic numbers are there?
2. Who was Nils Bohr? John Dalton?
3. To what is the atomic weight of an element equal?

Next assignment: Read "Adventures Inside the Atom."

Apr. 13. See filmstrip "The Atom." Shown and discussed. Questions raised by students the day before discussed and answered.

Apr. 14. New questions added to the list by students. New ideas from the filmstrip showing worked on. Other questions:
1. What are electron shells?
2. Who is Einstein and what was his contribution?
3. Into what does U235 split?
4. Why was plutonium used in the atom bomb?

Apr. 17. General review of principles; begin work on a new set of questions. See list at conclusion of time schedule.

Apr. 18. Continue review. Explain electron "shells."
New questions brought up:
1. Why are some elements stable?
2. Why do atoms form molecules?
3. What is a molecule?

Apr. 19. View film "Atomic Power."
Discuss film and study atomic number and weight.

Apr. 20. General review for test; spend remainder of this period in library working on the notebooks.

Apr. 21. Give test and take up the notebooks—Grade and discuss questions as answered in notebooks.

Apr. 24. Begin work on new questions (see list) and begin student's individual projects.

Apr. 25. See film "One World or None."
[Experience here showed that it would have been better to have used this film as an introduction to the unit. It caused the students to realize the importance of atomic energy. The first part of the film has the names and countries of men important in atomic research. However, this part of the film moves so rapidly that, unless some other introduction to these men of science has been made, the information is of little study value. Nevertheless, it is always possible to show this part of the film over again until the points are grasped.]

Apr. 26. Consider Einstein's equation and the relation of mass to energy to give idea of the power of the atom.

Apr. 27. Individual projects selected and discussion of information presented to date. Made clay models of atoms.

Apr. 28. Added new questions to the list for notebook work and began work on the individual projects.

May 1. No class period—School taking Iowa tests.

May 2. Show film "Principles of Electricity."
The first part of this film was found to be especially useful. It shows make-ups of how electricity acts.

May 3. More Iowa tests—no class.

May 4. Worked in library on individual reports and notebooks.

May 5. Worked on advanced questions and on individual projects.

May 8. Report of Geiger counter given; preparation for field trip to Willamette University on Tuesday made.

May 9. Journey to Willamette University to see Geiger counter and X-ray machines. Apparatus explained by Dr. Purbrick, University of Wisconsin wartime atomic researcher.

May 10. Discussion of field trip. Individual reports presented.

May 11. More individual reports; special projects demonstrated.

May 12. General evaluation of the unit; notebooks collected.

Questions for class and notebook work

I. What Is the Atom Like?

1. What are the building blocks of atoms?
2. How do atoms differ?
3. What makes one element different from another?
4. How large is an atom? An electron?
5. How do atoms combine to form molecules?
6. What are isotypes and why are they important?
7. What is the difference in size of electrons and neutrons?
8. What is radioactivity?
9. If the nucleus can break on its own accord is this radioactivity?
10. Name a substance with very large molecules.
11. Give an example of the breaking up of a molecule.
12. Name several radioactive elements.
13. What is the atomic number?
14. How many atomic numbers are there?

Correlated activities:

a. View film "Atomic Energy."
b. Diagram atoms for the notebooks.
c. Make a vocabulary list of atomic terms gathered from newspapers and magazine articles to add to what we have learned in class.

II. How Is Nuclear Energy Released?

1. What were some of the important scientific discoveries that led to the release of atomic energy?
2. By whom were they made? Give country also.
3. How can the atom be split?
4. What is a chain reaction? How accomplished?
5. What is the relationship between mass and energy?
6. What devices have been made to create the conditions necessary for splitting the atom?
7. How is the atomic bomb constructed? (theoretically, of course).
8. How is the chain reaction controlled in an atomic pile?
9. How many scientists produce atomic energy through fission of hydrogen atoms?
10. Account for the power of the "H-bomb."

III. The Use of Atomic Energy.

1. How can atomic energy be used for power? What are its limitations?
2. How are radioactive isotypes used in the study of plant life?
3. In what ways may the use of atomic energy aid in removing the drudgery and economic insecurity of certain levels of American life?
4. How are radioactive isotypes helpful in medical research and the war against disease?
5. Where is uranium found? What is the extent of our present known supply?
6. What other elements are found beyond #92?

In actual practice it was found that many of these questions overlapped; in fact the three general areas overlapped too. This was, however, truer of I and II than of area III, which dealt more specifically with the social and economic implications raised by the existence of atomic energy knowledge.

An atomic energy test

I. Diagram the following:

a The hydrogen atom.
b. An isotope of hydrogen.
c. The helium atom.
d. A chain reaction (be sure to label all parts).

II. Describe in complete detail how the energy of the sun is obtained.

III. Give answers, in complete sentences, to the following:

a. What are the parts of an atom?
b. How much electrical charge does a neutron have?
c. What are electron shells?
d. What are charges?
e. How is the atomic weight found?

IV. Give an example of a molecule and tell what it is composed of.

V. Indicate whether the following statements are true or false and give the reason for your answer:

a. The atomic number of hydrogen is one.
b. Uranium 238 is a stable element.
c. The atom bomb was inclosed in an electron shell.
d. Uranium 235 and 238 are alike except for the number of protons.
e. With our present atomic knowledge it is now possible for man to make diamonds or gold.

VI. What do you think of the future for peacetime atomic utilization?

Notebooks and Scrapbooks

In addition to the use of the notebook as a repository for atomic information gained in class and in the library, it also served as a scrapbook. Much current material from magazines, newspapers, and other sources found its way here. A particular feature of this notebook-scrapbook was the inclusion of "atomic paragraphs" in which pertinent clippings were attached and then commented upon by the student. Since some of these reactions seem to serve as an additional evaluation of the worth of the project in developing attitudes and understandings, a few of them are submitted.

Thus, Parrish junior high school students considered that:

"It would be better to have the UN control the atomic power all together; then there would be no war. But since the U. S. and Soviet Russia can't agree (this was written before Korea, of course) we are always going to have this fear of an atomic war."

"The world can do so much with the new knowledge we have gained if we can only have peace."

"I think they had better work with a few more animals before they try it on human beings because often drugs that they give lower animals don't always help humans."

"I think this proves that we are learning more and more. But if the scientists aren't careful they will blow up the whole world."

"The H-Bomb is the most powerful weapon to destroy mankind. Personally, I hope that it is never 'discovered'."

"This article shows what the future may bring to our land. We will use atomic energy for peace and war."

"I think, some day, atomic energy will be used for propelling ships. It will really be wonderful when it is perfected."

"A Geiger counter should be made at such a price that the average person can afford it. Some day he may need it for his own protection."

"I still think that atomic energy will have to be controlled pretty well before being used for children's toys." (Was this irony?)

A notebook cover, too, pretty well sums up student conclusion formed through the atomic energy unit study. The caption on this folder asks "WHICH IS TOMORROW?" It shows a picture, student-drawn, of a boy and a girl holding hands looking to the right in the direction of a pleasant city with green grass, clean streets, and a smiling sun; to the left is a blackened, pall-hung, Nagasaki.

*We must teach for tomorrow.**

* Published after Miss LeFiles taught the unit described is the United States government issued "The Effects of Atomic Weapons," which may be secured from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. Price $1.25.

This book is fully illustrated with nearly 150 line drawings, and over 60 halftone plates. It contains "hitherto unpublished details on atomic explosions."

The material for "The Effects of Atomic Weapons" was contributed by more than 100 military and scientific authorities.

Unfortunately, its 438 pages are devoted only to the destructive aspects of atomic fission. The starkness of this fact, alone, invites a wider study of the possibilities of atomic energy for peace. Needless to say, the schools should be put in position to do their part.

REVISED TEACHING AIDS CATALOGUE AVAILABLE THROUGH WESTINGHOUSE

A revised 24-page Teaching Aids Catalogue for 1951–1952, describing over 85 free and inexpensive booklets, charts, posters, and other audio-visual materials currently available to junior and senior high school teachers, is available from the School Service Department of the Westinghouse Electric Corporation.

These teaching aids cover a wide range of subjects including aids in science, social studies, agriculture, home economics, industrial arts, and photography. The catalogue also has sections on audio-visual aids, lighting the school plant, technical publications, and Westinghouse Scholarships available to students and teachers.

Each catalogue contains order blanks for use in requesting desired materials.

Teachers can obtain copies of this Teaching Aids Catalogue (B-5408) by writing to the School Service Department, Westinghouse Electric Corporation, P.O. Box 1017, Pittsburgh 30, Pa.

ORDER BOOK, CATALOG AND INVENTORY ROOM

Central Scientific Company has just issued a new 32 page combination Order Book, Catalog and Inventory Form, listing laboratory apparatus and supplies for secondary school science, physics, chemistry and biology. It is alphabetically arranged and divided into four classifications: Chemistry Apparatus, Laboratory Chemicals, Biology Apparatus and Physics Apparatus.

The apparatus is illustrated in separate panels alongside of the inventory forms making a new convenience for ordering and listing. Copies will be sent on request. Write Central Scientific Company, 1700 West Irving Park Road, Chicago 13, Illinois for Order Book 52.

PROVIDING APPARATUS AND EQUIPMENT FOR TEACHING HIGH SCHOOL CHEMISTRY*

FRED W. MOORE
Senior High School, Owosso, Michigan

The amount and kind of apparatus needed to teach the physical sciences will be largely determined by the purposes or objectives that the teacher has in mind in conducting such a course. Therefore, it might be well to spend a few moments in reviewing some of the purposes of laboratory work in connection with the physical sciences.

In the Forty-Sixth Year Book of the National Society for the Study of Education, which book is devoted to the teaching of science, Elwood Heiss thinks that at least some of the objectives that should be kept in mind for the laboratory part of a science course are:

1. Practice in raising and defining worthwhile problems in science.
2. Conduct laboratory sessions in such a way that pupils will learn the meaning and use of controls in experimentation.
3. To test various hypotheses and interpret the data that they collect in the experiment, and use that data as evidence for drawing conclusions with reference to the problem at hand.

Professor Webb has recorded back in the Thirty-First Year Book that a good course in Laboratory Science should make a definite contribution to the ability of the pupils to be resourceful. It allows for greater display of individual differences, and it provides for the "learning by doing" experience which gives skill and technique to carry out simple experiments. Probably any experienced teacher would have certain variations from these general objectives of laboratory work, and yet, it seems to me, that they summarize the more important aspects of what we are trying to do in the science laboratory: if the class discussion has been carried on in such a way that these so called "worthwhile problems" have been raised and an opportunity has been given the pupil to try his hand at designing an experiment to solve these problems, if you are going to let students have a rather wide range of methods to follow in solving a particular problem, or if you are just going to perform a definite number of experiments as suggested by the regular manual. The various approaches will determine the amount and the kind of apparatus needed.

I am sure that every good course needs to give pupils a wide choice of experimenting in addition to the rather fundamental and standard experiments which are common to all good science courses. It has been my own experience that at the beginning of the course in

* An address delivered at the Annual Conference of High School Teachers of Science, University of Michigan, May 12, 1951.

chemistry it is necessary for the teacher to show by demonstration the simple procedures that are common to all experiments. I like to show the pupils, before they have an opportunity to cut their fingers or burn them or otherwise endanger themselves, how to handle glassware, the burners, make simple adjustments, put together apparatus in a usable fashion.

After some demonstrations and the students are allowed to go into the laboratory for the first few experiments, the major emphasis should be on carrying out directions and assembling apparatus correctly and getting used to watching a chemical experiment proceed so that they are aware of some of the sources of error.

The equipment, therefore, that is needed to conduct these early experiments in chemistry should be at hand for each student so they will be able to spend all of their available time in assembling their apparatus, carrying out their experiment, and concentrating their thought and attention on the experiment itself.

This means that each student should have available for his own personal use a good selection of chemical apparatus.

I have found that a supply of fifteen or twenty pieces of equipment for each student locker is sufficient to carry on the usual experiments that are found in the chemistry course. This list appears as "A" on the data sheet.

Then there are certain other items of equipment which should be available for the students at all times and which, since there is little danger of breakage or stealing may well be shared in common with students working at the same desk in other classes. This list appears as "B" on the data sheet. This material has been adequate to meet the needs of the ordinary students in performing those experiments which have been outlined by the text.

As far as I am able to observe we have had none of this apparatus stolen from the laboratory for years, and it seems to me that the freedom that the students have in going and getting the apparatus that they need gives them a sense of being real scientists; knowing they are trusted with the equipment needed to carry out any extra experiment.

Because I believe that the student needs to come to the place where his attention is not centered primarily upon the apparatus itself, we spend the early days in laboratory in just getting acquainted with the various apparatus, doing simple experiments that do not have an important chemical bearing from the learner's standpoint and allow them to get out of their system that activity that their normal curiosity demands. I believe this a profitable few days in the laboratory when they are rather free to do various things to see how the equipment works; the folding of filter paper, filtering solutions,

making precipitates, evaporating solutions to dryness, lighting and adjusting the Bunson burner, heating solids and liquids, collecting gases in bottles, by simply blowing through the delivery tube into the bottle filled with water.

After a couple of days of this orientation period they are ready to use the apparatus as a means to an end rather than an end in itself.

Two chemical balances at the side of the room, a desiccator by the hood, a bottle of distilled water, fed by a siphon are also available for the students at all times. We have three locations for chemicals used by the students. At the back of our laboratory we have a series of shelves on which are placed about fifty 500 ml glass stoppered reagent bottles containing the solutions needed throughout the year. On another shelf we have approximately forty bottles containing the dry reagents that are most commonly used; and on a stone top table the large two-liter bottles of the acids and bases similar to the small reagent bottles on each student's desk, so that he may fill his own bottles whenever necessary. The liquid reagents in use for the current experiments are also put over on this shelf to make them more accessible.

Therefore when the pupil comes into the laboratory he knows where the equipment and chemicals are usually kept. A laboratory assistant who is a former chemistry pupil now enrolled in Physics, serving full time in the laboratory hours takes care of keeping reagent bottles in place and filled at all times, getting out stock and putting it away and doing most of the physical work to keep the laboratory in a running order. A laboratory assistant is a great help in any chemistry laboratory.

The equipment and apparatus mentioned so far is that which is required for doing experiments that are in the manual and the ones that most of the students do throughout the year. And yet in carrying out some of the objectives that every good laboratory course should have, students will be asked and encouraged to do other things, besides those which are directed in the manual. If I have in mind the teaching of the importance of just plain honesty in a chemical experiment, I often ask the student when he is preparing and testing hydrogen, "What is the product formed when hydrogen burns in the air?" They automatically answer, water vapor. Then I ask them if their experiment has given them proof of that. And after thinking a moment and remembering that the bottle containing the hydrogen was full of water a few minutes before, then they are not so sure that they have actually proved that water is formed in the burning of hydrogen. Although they are sure that it is obviously true, and the book says so, so why isn't it? Yet before many of the better students are satisfied, someone will volunteer to set up the apparatus needed

to prepare hydrogen, dry it from all apparent moisture, burn it and collect the water vapor that is actually formed from the burning of hydrogen, in a dry tube or other suitable container. This involves the use of our filter pump, the drying tubes and an apparatus that they may use their own originality in designing.

I believe whenever time will permit if we press the students for actual proof from their experiment for the conclusions which they draw they will find that other experiments are necessary before they can be sure that what they have written down in the note book as their answer was actually justified by the experiment in hand. It seems reasonable that the students should do some quantitative work in high school chemistry; so during the first semester they are required to calculate the per cent of water of crystalization in crystalized barium chloride. This requires the use of the balance, a desiccator, care in weighing and keeping the record and calculating an actual mathematical result from their own work.

The second semester our students are asked to select and carry out any original quantitative experiment. This often takes the form of analyzing various foods or fuels for the per cent of carbon; analyzing the stones and rocks for the amount of iron or calcium present, analyzing various inorganic products for various ingredients, which are usually found therein. This gives them a rather wide range of opportunity to do experiments which are along the line of their own inclinations and so several items of equipment are going to be used if they are to be encouraged to do whatever they feel is worthwhile in their own experience. For this purpose I have found it very convenient to have available the list of special apparatus listed in "C" on the data sheet.

Since the assistants do not receive any financial remuneration for their services in the laboratory, but only school credit, I like to encourage them to use this as an opportunity for going on in chemistry and doing other things that were not possible during their first year in chemistry. This has led me to purchase a set of semi-micro equipment and that apparatus needed to carry out some of the simpler manipulations using this type of equipment. The desires of the assistants have also led to the purchasing of a large number of different chemicals, never used by the regular students, but available to those who care to go beyond the regular work in high school chemistry.

Since much of the chemistry course is given over to what might be called descriptive chemistry, studying metallurgical methods and how to prepare various finished manufactured products from the raw materials, I have found it very convenient to have rather large

boxes assembled in which I can place samples of the minerals, the metal itself, various alloys, if possible, and applications of how it is used in the industry, the home and in normal life and any odd literature that might be appropriate.

CHEMISTRY DATA SHEET

A

1 Crucible with cover
1 Watch glass
1 Evaporating dish
1 Funnel
6 Pyrex test tubes
1 8" large soft glass test tube
1 Small test tube
1 Test tube stand
2 150 ml. beakers
1 250 ml. Flask
2 Rubber delivery tubes
1 Thistle tube
1 Triangle
2 Rubber stoppers

B

mortar and pestle
rubber covered beaker tongs
crucible tongs
bunsen burner
ring stand
large ring
small ring
clamp
pneumatic troughs
wide mouth bottles
glass cover plates
25 ml. graduate cylinder
100 ml. graduate cylinder
bottles of the five common acid and base reagents
wooden splints
filter paper
T-tubes
extra rubber tubing

C

electric hot plate with thermostat control
electric furnace with quartz tube for holding combustion boat
individual desiccators
filter pump on water faucet
leibig condenser
reflux condenser
U-tubes and drying tubes
motor driven stirrer
colloid mill
various volumetric flasks
up to 12" evaporating dishes
casseroles
weighing bottles
crystallizing dishes
glass beads
filter flask
filtering crucibles
Fisher burners
distilling retorts
burettes-pipettes
gas washing bottles
gas measuring tubes
graduate cylinders up to 1000 ml.
burner guards
beakers up to 2 liters
hand balances
white base burette stand
various thermometers
Hydrion paper
cobalt glass
ignition tubes
nickel crucible
iron crucibles

I have found this a very convenient way to keep up to date on my samples involved; for instance, in studying lead, we have collected a sample of some of the various ores of lead, a lead ingot, and then various alloys containing lead, and where possible actual samples of the piece that includes the alloy. As old uses become obsolete they

can be removed from the box. As new ones come in they can be added. A certain amount of literature can also be kept in this box.

Every laboratory and successful chemistry department I am sure, has a collection of charts and large illustrations that can very appropriately be used to help the student visualize the place that element or compound occupies in modern life. The storage and use of these presents a real problem to the alert chemistry teacher. A certain amount of home-made models of furnaces and other industrial applications of chemistry are always convenient and useful in giving to students an actual picture of the way in which chemical changes are carried out in industry.

The fact that our students are changing every year as well as the general effect of science in ordinary life, it behooves the alert science teacher to build up reserves of chemicals and apparatus, to get materials for prospective experiments and to be on the alert for new experiments available for their students. I have found that such books as *Cenco News Chats*, *Fisher's Laboratory*, *Welch's New Physics Digest*, SCHOOL SCIENCE AND MATHEMATICS, *Journal of Chemical Education*, *The Science Teacher Magazine*, as well as the standard reference works on Lecture Demonstration and Experiments are all of great help in keeping us alert to possible experiments that will add interest, variety, and real value to our high school science courses

SAFETY PLANE FOR PRIVATE FLYING SLOWS TO 35-MILE RATE

A safer airplane for private flying, demonstrated here, took off and landed repeatedly from a 100-yard runway and made turns at low altitude while traveling at a speed of 35 miles an hour.

The new plane is called the Helio Courier, but it is a plane and not a helicopter. It is an adaptation of an experimental plane, known as the Helioplane, demonstrated two years ago which was designed by Prof. Otto C. Koppen, of Massachusetts Institute of Technology, and Dr. Lynn L. Bollinger of Harvard University. Helio Aircraft Corporation, Norwood, Mass., is the builder.

This craft is a high-wing monoplane which uses a geared 260 horsepower engine. Crusing speed is 150 miles an hour. It can carry six people. A particular feature in addition to its safety is the ability to use an in-town small landing field or a landing strip close to a manufacturing plant, handy for the owner's use.

By skillful combination of long-known high-lift wing devices, including large flaps similar to types used on the wings of large airliners, plus a unique control system, the Helio Courier makes it possible to combine the efficient high-speed and pay-load of the modern executive type place with low speed landing and short take-off ability.

Razor blade sharpener, an improved type operated electrically that enables a double-edge blade to give 100 good shaves, has six revolving leather rollers, two of which are impregnated with a fine abrasive. It operates on either direct or alternating household current.

A PRESSURE DEMONSTRATION

JOSEPH A. MACK
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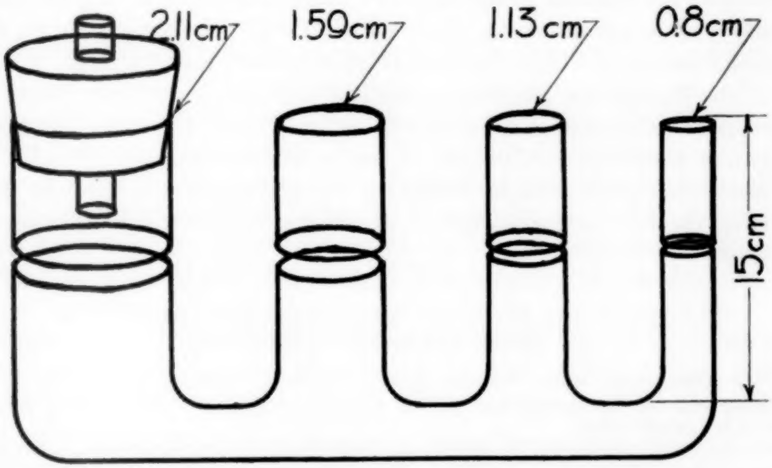
One of the annually recurring difficulties of the physics course is the failure of the slow-learner to grasp the concept of pressure. This happens especially when the areas under consideration are not unit areas. This difficulty is encountered in the case of liquid as well as in gas pressures. How often does one not hear murmured, "I don't get that!" when atmospheric pressure is measured by a small bore barometer.

Being a believer in the "one picture (or demonstration) is worth a thousand words," we set out to remedy the difficulty by devising a demonstration. Analysis showed the difficulty had a few compo-



ALL DIAMETERS INTERIOR

nents. We concluded that a multitube manometer does help. This piece must not be mistaken for that "tortured glass" which is intended to demonstrate that liquids stand at the same level in communicating vessels. Neither is this apparatus to be confused with the capillary demonstration piece which it closely resembles. Essentially the multiple manometer consists of three or more open tubes having a definite ratio to each other, connecting through a cross-tube at their bases to a reservoir or well. These open manometer tubes have a cross-sectional ratio of 1:2:4. When the correct diameters of glass tubing are used these tubes will have areas of ½ sq. cm., 1 sq. cm. and 2 sq. cm. The well or reservoir should be of such dimensions as to equal the sum of these areas, so that the volume of liquid in the three

open manometer tubes can be accommodated in the well. This well is stoppered with a one-hole stopper through which both positive and negative pressures may be applied. The most convenient demonstration is with lung pressures. Since both water and mercury may be used as liquid, the range of pressures covered seems ample. When mercury is used as the liquid the manometer tubes need not be longer than 15 cm.

The depth of the liquid in the well should be about one half the effective height of the manometer tubes to allow both positive and negative pressures to be demonstrated at one filling. By using liquids of different densities (mercury and water) in different trials, most questions could be answered.

One of the student's difficulties can be eliminated when he sees that the liquids stand at the same height in the three tubes as different pressures are applied to the well. To make the water pressures more easily visible the usual fuchsine solution may be used. Also, an alkaline solution of Congo Red can be made to any color density.

If the liquids are put into a shallow dish or pan and the piece is inverted so that the manometer tubes are under the liquid surface, negative pressures can provide another demonstration.

Must this apparatus be made by the physics instructor? At this writing there is none available from the scientific instruments supply houses.

FLOOD-DAMAGED MICROFILM RECORDS RESTORED IN HUGE SALVAGE OPERATION

Milk cans, wash tubs, and any containers able to hold water helped save millions of rolls of important microfilm records during the recent Kansas flood, it was revealed today.

The records were owned by banks, railroads, industries, retail stores, and other business firms whose offices had been deluged by the worst flood in U. S. history.

Advised by the Recordak Corporation, an Eastman Kodak Company subsidiary, to put flood-damaged microfilm under water and ship it to the corporation's Kansas City laboratories, the business firms used every type of container available to rush their films for restoration.

Operating on an emergency round-the-clock schedule, the processing station washed, dried, and rewound all the microfilm onto new spools. For filing convenience, the original 16-mm. boxes were returned with the newly packaged film.

One bank in the flooded area shipped more than 2,000 rolls of microfilm records of checks and bank statements for reclamation. Wash tubs full of microfilm rolls were salvaged for a large industrial firm. Following cleaning and respooling, the records were legible and in good condition except for a few images on the outer layers of the film rolls.

Flute for the youngster made of plastic materials is tunable to the piano by a turn on the mouthpiece. Practically unbreakable, it features clear tone, full chromatic scale and easy fingering. It can be washed in warm water and soap without damage to resonance or finish.

SRINIVASA RAMANUJAN

A BIOGRAPHICAL SKETCH

JULIUS SUMNER MILLER
Dillard University, New Orleans 22, La.

"I remember once going to see him when he was lying ill at Putney. I had ridden in taxi cab No. 1729, and remarked that the number seemed to me rather a dull one, and that I hoped it was not an unfavorable omen. 'No,' he replied, 'it is a very interesting number; it is the smallest number expressible as a sum of two cubes in two different ways.' I asked him, naturally, whether he knew the answer to the corresponding problem for fourth powers; and he replied after a moment's thought, that he could see no obvious example, and thought that the first such number must be very large." (Euler gave $158^4+59^4=133^4+134^4$ as an example.)

Thus does Professor G. H. Hardy report on an incident with Ramanujan.

Srinivasa Iyengar Ramanuja Iyengar, to give him his proper name, was one of the most remarkable mathematical geniuses of all time. This is especially true when the circumstances of his birth and life are intimately considered. It is difficult, indeed, for the student of the history of science to encounter a more astonishing biography. As Einstein so classically puts it: "Nature scatters her common wares with a lavish hand but the choice sort she produces but seldom." We will see, in this sketch, how closely this borders on a miracle.

Ramanujan, as he is commonly known, was born of a Brahmin family in the ever-so-present poverty that abounds in India. His ancestry, it appears, contributed nothing noteworthy to his great gifts. His mother was a woman of strong character. In accordance with custom her father prayed to the famous goddess Namagiri to bless her with children, and on December 22, 1887, this son was born. He started school at five. His early years showed no unusual signs of his special abilities although he was remarkably quiet and meditative, and he led his class. While in the "second form" he expressed a curiosity about the "highest truth in Mathematics." In the "third form" he was taught that any quantity divided by itself was unity whereupon he asked if zero divided by zero was also equal to unity! While in the "fourth form" he studied trigonometry and solved all the problems in the text without any aid whatsoever. In the "fifth form" he obtained unaided Euler's Theorems for the sine and cosine. When he found that these were already proved he hid his papers in the roof of his house. While in the "sixth form" he borrowed Carr's *Synopsis of Pure Mathematics* and this book appears to have awakened his genius. He took great delight in verifying all the formulae therein and since he had no aid whatsoever, each solution was original re-

search. He entertained his friends with recitation of formulae and theorems and demonstrated his remarkable memory by repeating values of *pi* and *e* to any number of decimal places. In every respect, however, he was utterly simple in his habits and unassuming.

He took up Geometry a little and by "squaring the circle" approximated the earth's circumference with an error of only a few feet. The scope of Geometry being limited in his judgment, he concerned himself with Algebra and obtained several new series. He said of himself that the goddess of Namakkal inspired him in his dreams and the remarkable fact is that on rising from bed he would at once write down results although he was not able to supply a rigorous proof. These results he collected in a notebook which he later showed to mathematicians.

In December 1903 (he was now only 16) he matriculated at the University of Madras and in 1904 won the "Junior Subrahmanyam Scholarship" at the Government College in Kumbakonam, this being awarded for proficiency in English and Mathematics. His absorption in mathematics, however, which was no less than devotion, led him to neglect his other work, and he failed to secure promotion. Indeed, he could be found engaged in some mathematical inquiry quite unmindful of what was happening in the class, whether it be English or History or anything else. For the next few years he pursued independent work in mathematics "jotting down his results in two good-sized notebooks." In the summer of 1909 he married. His greatest need was employment and this was a difficult matter for his family was poor, his college career a dismal failure, and he himself without influence.

In search of some means of livelihood he went, in 1910, to see one Mr. V. Ramaswami Aiyar, the founder of the Indian Mathematical Society. Aiyar, himself a mathematician of first order, found Ramanujan's notebooks remarkable and knew at once that this man possessed wonderful gifts. Accordingly, it was arranged that this unusual genius meet one Ramachandra Rao, a "true lover of mathematics," and a man in position to assist him. In December of 1910 Rao interviewed Ramanujan and Rao's own report of this meeting is a classic:

> " . . . a nephew of mine perfectly innocent of mathematical knowledge said to me, 'Uncle, I have a visitor who talks of mathematics; I do not understand him; can you see if there is anything in his talk?' And in the plenitude of my mathematical wisdom I condescended to permit Ramanujan to walk into my presence. A short uncouth figure, stout, unshaved, not overclean, with one conspicuous feature—shining eyes—walked in with a frayed notebook under his arm. He was miserably poor. He had run away from Kumbakonam to get leisure in Madras to pursue his studies. He never craved for any distinction. He wanted leisure; in other words, that simple food should be provided for him without exertion on his part and that he should be allowed to dream on.

"He opened his book and began to explain some of his discoveries. I saw quite at once that there was something out of the way; but my knowledge did not permit me to judge whether he talked sense or nonsense. Suspending judgment, I asked him to come over again, and he did. And then he had gauged my ignorance and shewed me some of his simpler results. These transcended existing books and I had no doubt that he was a remarkable man. Then, step by step, he led me to elliptic integrals and hypergeometric series and at last his theory of divergent series not yet announced to the world converted me. I asked him what he wanted. He said he wanted a pittance to live on so that he might pursue his researches."

With all speed Rao sent Ramanujan back to Madras saying that it was cruel to make an intellectual giant like him rot away in obscurity, and he undertook to pay his expenses for a time. Since he was not happy being a burden to anybody for long, he took a small job in the Madras Port Trust office.

In the meanwhile his mathematical work was not slackened and during these years (1911–1912) he made his first contributions to the Journal of the Indian Mathematical Society. His first long article was on "Some properties of Bernoulli's Numbers" and he contributed also a number of questions for solution. Mr. P. V. Seshu Aiyar, through whom Ramanujan's papers were communicated, describes the work thus:

"Ramanujan's methods were so terse and novel and his presentation was so lacking in clearness and precision, that the ordinary reader, unaccustomed to such intellectual gymnastics, could hardly follow him."

Having thus gained a little recognition he fell heir to every encouragement and was thus brought to communicate with Professor G. H. Hardy, then Fellow of Trinity College, Cambridge. His first letter to Hardy bears more eloquence than is reasonable to expect of him and, indeed, Hardy did not believe that his letters were entirely his own. In this connection Hardy said: "I do not believe that his letters were entirely his own. His knowledge of English, at that stage of his life, could scarcely have been sufficient, and there is an occasional phrase which is hardly characteristic. Indeed I seem to remember his telling me that his friends had given him some assistance. However, it was the mathematics that mattered, and that was very emphatically his." His first communication to Hardy is a classic worth reciting:

Madras, 16th January, 1913

"Dear Sir,

I beg to introduce myself to you as a clerk in the Accounts Department of the Port Trust Office at Madras on a salary of only 120 per annum. I am now about 23 years of age. I have had no University education but I have undergone the ordinary school course. After leaving school I have been employing the spare time at my disposal to work at Mathematics. I have not trodden through the conventional regular course which is followed in a University course, but I am striking out a new path for myself. I have made a special investigation of diver-

gent series in general and the results I get are termed by the local mathematicians as 'startling.'"

(He proceeds to discuss his interpretations of a certain integral and says)

"My friends who have gone through the regular course of University education tell me that the integral is true only when n is positive. They say that this integral relation is not true when n is negative. . . . I have given meaning to these integrals and under the conditions I state the integral is true for all values of n negative and fractional. My whole investigations are based upon this and I have been developing this to a remarkable extent so much so that the local mathematicians are not able to understand me in my higher flights.

"Very recently I came across a tract published by you styled *Orders of Infinity* in page 36 of which I find a statement that no definite expression has been as yet found for the number of prime numbers less than any given number. I have found an expression which very nearly approximates to the real result, the error being negligible. I would request you to go through the enclosed papers. Being poor, if you are convinced that there is anything of value I would like to have my theorems published. I have not given the actual investigations nor the expressions that I get but I have indicated the lines on which I proceed. Being inexperienced I would very highly value any advice you give me. Requesting to be excused for the trouble I give you.

I remain, Dear Sir, Yours truly,
S. Ramanujan"

The papers he enclosed contained a hundred or more mathematical theorems. Some of his proofs were invalid for, after all, he was ignorant of very much of modern mathematics. He knew little or nothing of the theory of functions of a complex variable. He disregarded the precepts of the Analytic Theory of Numbers. His Indian work on primes was definitely wrong. But Hardy puts it beautifully:

"And yet I am not sure that, in some ways, his failure was not more wonderful than any of his triumphs." (He had none of the modern weapons at his command.) "He had never seen a French or German book; his knowledge even of English was insufficient to enable him to qualify for a degree. It is sufficiently marvelous that he should have even dreamt of problems such as these, problems which it has taken the finest mathematicians in Europe a hundred years to solve, and of which the solution is incomplete to the present day."

In his second letter to Hardy he wrote as follows:

" . . . I have found a friend in you who views my labours sympathetically. This is already some encouragement to me to proceed." (Follows a comment on an infinite series.) "If I tell you this you will at once point out to me the lunatic asylum as my goal. . . . What I tell you is this. Verify the results I give and if they agree with your results . . . you should at least grant that there may be some truths in my fundamental basis. . . .

"To preserve my brains I want food and this is now my first consideration. Any sympathetic letter from you will be helpful to me here to get a scholarship either from the University or from Government. . . . "

Hardy sensed at once that here was a mathematician of the very highest class and he proceeded at once to arrange for Ramanujan to come to England. The Indian's caste prejudices, however, were very strong, and he declined to go. This was a heavy disappointment to Hardy. After many persuasive letters and the influence of Indian friends Ramanujan had almost made up his mind to go but a new

difficulty arose. His mother would not consent. This was overcome by a most unusual episode. His mother suddenly announced that she had a dream in which she saw her son seated in a big hall amidst a group of important Europeans, and that the goddess Namagiri, who had blessed her with this son, had commanded her not to stand in his way. At this time another Fellow of Trinity, Mr. E. H. Neville, who was delivering a course of lectures at Madras and who was acting as an ambassador for Hardy in urging Ramanujan to come to England, wrote a note to the authorities at the University of Madras:

> "The discovery of the genius of S. Ramanujan of Madras promises to be the most interesting event of our time in the mathematical world. . . . The importance of securing to Ramanujan a training in the refinements of modern methods and a contact with men who know what ranges of ideas have been explored and what have not cannot be overestimated. . . .
>
> "I see no reason to doubt that Ramanujan himself will respond fully to the stimulus which contact with western mathematics of the highest class will afford him. In that case his name will become one of the greatest in the history of mathematics and the University and the City of Madras will be proud to have assisted in his passage from obscurity to fame."

The University authorities at Madras approved a grant, good in England for two years, with passage and a sum for outfitting him. Of this Ramanujan arranged to have a certain portion allotted to the support of his family in India. He sailed for England on March 17, 1914, being then 27 years of age. In April he was admitted to Trinity College where his grant was supplemented. For the first time in his life he was free of anxiety and certain of food, clothing and lodging. His requirements were so painfully simple that out of the scholarship monies he was able to save a goodly bit. Indeed, Professor Hardy describes his tastes as "ludicrously simple."

Now with Ramanujan among them the British mathematicians found themselves in a very certain dilemma. His knowledge of modern mathematics, of what had been explored in the mathematical world, was limited beyond belief. Indeed, "The limitations of his knowledge were as startling as its profundity. Here was a man who could work out modular equations, and theorems of complex multiplication, to orders unheard of, whose mastery of continued fractions was, on the formal side at any rate, beyond that of any mathematician in the world, who had found for himself the functional equation of the Zeta-function, and the dominant terms of many of the most famous problems in the analytic theory of numbers; and he had never heard of a doubly periodic function or of Cauchy's theorem, and had indeed but the vaguest idea of what a function of a complex variable was. His ideas as to what constituted a mathematical proof were of the most shadowy description. All his results, new or old, right or wrong, had been arrived at by a process of mingled argument, in-

tuition, and induction, of which he was entirely unable to give any coherent account.

"It was impossible to ask such a man to submit to systematic instruction, to try to learn mathematics from the beginning once more. I was afraid, too, that if I insisted unduly on matters which Ramanujan found irksome, I might destroy his confidence or break the spell of his inspiration. On the other hand there were things of which it was impossible that he should remain in ignorance. . . . So I had to try to teach him, and in a measure I succeeded, though obviously I learnt from him much more than he learnt from me. In a few years' time he had a very tolerable knowledge of the theory of functions and the analytic theory of numbers. He was never a mathematician of the modern school, and it was hardly desirable that he should become one; but he knew when he had proved a theorem and when he had not. And his flow of original ideas shewed no symptom of abatement."

Everything went well until the spring of 1917. Ramanujan published his papers in the English and European journals. All reports of him carried the highest praise. Mr. Hardy's report is particularly fine:

> "Ramanujan has been much handicapped by the war. Mr. Littlewood, who would naturally have shared his teaching with me, has been away, and one teacher is not enough for so fertile a pupil. . . . He is beyond question the best Indian mathematician of modern times. . . . He will always be rather eccentric in his choice of subjects and methods of dealing with them. . . . But of his extraordinary gifts there can be no question; in some ways he is the most remarkable mathematician I have ever known."

In the spring of 1917 Ramanujan showed signs of being not well. Since return to India was out of the question, sea travel was dangerous and medical men in India were scarce, he was placed in a sanatorium. From this time on he was never out of bed for any length of time again. He recovered slightly and two years later sailed for home. The climate of England did not lend itself to his stamina in the first place nor was it conducive to his recovery after he showed positive evidence of being tubercular.

While in England he was elected a Fellow of the Royal Society, thus being the first Indian on whom the honor was conferred. His age was 30. This together with the fact that he was elected the very first time his name was proposed is a tribute of first magnitude to his remarkable genius. This honor appears to have incited him to further production for it was during these days that he discovered some of his most beautiful theorems. In that same year he was elected a Fellow of Trinity College, a prize fellowship worth some 250 pounds a year for six years, with no duties and no conditions. At this time Hardy wrote to the University of Madras as follows:

"He will return to India with a scientific standing and reputation such as no Indian has enjoyed before, and I am confident that India will regard him as the treasure he is."

In honor of Ramanujan's contributions to Mathematics the University of Madras made a further grant of 250 pounds a year for five years as well as covering travel between England and India as he chose. But Ramanujan was a sick man and of his election to these honors Hardy said "and each of these famous societies may well congratulate themselves that they recognized his claims before it was too late."

Having returned to India he was put in the best medical care and many persons contributed to his support. One Indian gentleman covered his entire expenses, another gave him a house free. But these served him not too well. On April 26, 1920, just about a year after his return to India, he died. He left no children. Only his parents and his wife survived him.

Regarding his appearance and personality, "before his illness he was inclined to stoutness; he was of moderate height (5 feet 5 inches); and had a big head with a large forehead and long wavy dark hair. His most remarkable feature was his sharp and bright dark eyes. . . . On his return from England he was very thin and emaciated and had grown very pale. He looked as if racked with pain. But his intellect was undimmed, and till about four days before he died he was engaged in work. All his work on 'mock theta functions,' of which only rough indications survive, was done on his deathbed."

Ramanujan had very definite religious views and adhered even in England with unusual severity to the religious observances of his caste. He believed in the existence of a Supreme Being and possessed settled convictions about life and life-hereafter. "Even the certain approach of death did not unsettle his faculties or spirits . . ." Hardy relates: " . . . and I remember well his telling me (much to my surprise) that all religions seemed to him more or less equally true."

In his manner he was utterly simple and without conceit. Of these characteristics Hardy wrote: "His natural simplicity has never been affected in the least by his success." That he possessed a charitable heart is beautifully illustrated in this letter:

To The Registrar,
University of Madras.

Sir,

. . . .

I feel, however, that, after my return to India, which I expect to happen as soon as arrangements can be made, the total amount of money to which I shall be entitled will be much more than I shall require. I should hope that, after my expenses in England have been paid, L50 a year will be paid to my parents and that the surplus, after my necessary expenses are met, should be used for some

educational purpose, such in particular as the reduction of school-fees for poor boys and orphans and provisions of books in schools. No doubt, it will be possible to make an arrangement about this after my return.

I feel very sorry that, as I have not been well, I have not been able to do so much mathematics during the last two years as before. I hope that I shall soon be able to do more and will certainly do my best to deserve the help that has been given me.

I beg to remain, Sir,
Your most obedient servant,
S. Ramanujan

It remains finally to give some estimate of Ramanujan's mathematics. For this the only sensible and proper source is Professor Hardy's account for all of Ramanujan's manuscripts passed through his hands. Hardy edited all of them and reworte the earlier ones completely. In some he collaborated. In this connection Hardy writes: "Ramanujan was almost absurdly scrupulous in his desire to acknowledge the slightest help." It is obviously impossible to give a value in the proper sense to Ramanujan's mathematics; all we can do is quote freely from Hardy's own remarks.

" . . . Some of it is very intimately connected with my own, and my verdict could not be impartial; there is much too that I am hardly competent to judge. . . .

" . . . But there is much that is new, and in particular a very striking series of algebraic approximations to π. I may mention only the formula

$$\pi=\frac{63}{25}\,\frac{17+15\sqrt{5}}{7+15\sqrt{5}}, \qquad \frac{1}{2\pi\sqrt{2}}=\frac{1103}{99^2}$$

correct to 9 and 8 places of decimals respectively."

" . . . but the elementary analysis of 'highly composite' numbers—numbers which have more divisors than any preceding number—is most remarkable, and shews very clearly Ramanujan's extraordinary mastery over the algebra of inequalities. . . . "

" . . . They contain, in particular, very original and important contributions to the theory of the representation of numbers by sums of squares."

" . . . But I am inclined to think that it was the theory of partitions, and the allied parts of the theories of elliptic functions and continued fractions, that Ramanujan shews at his very best."

"It would be difficult to find more beautiful formulae than the 'Rogers-Ramanujan' identities. . . . "

"He had, of course, an extraordinary memory. He could remember the idiosyncracies of numbers in an almost uncanny way. It was Mr. Littlewood (I believe) who remarked that 'every positive integer was one of his personal friends.' "

"His memory, and his powers of calculation, were very unusual."

"It was his insight into algebraical formulae, transformations of infinite series, and so forth, that was most amazing. On this side most certainly I have never met his equal, and I can compare him only with Euler or Jacobi. He worked, far more than the majority of modern mathematicians, by induction from numerical examples."

"But with his memory, his patience, and his power of calculation, he combined a power of generalization, a feeling for form, and a capacity for rapid modification of his hypotheses, that were often really startling, and made him, in his own peculiar field, without a rival in his day."

"Opinions may differ as to the importance of Ramanujan's work, the kind of standard by which it should be judged, and the influence which it is likely to have on the mathematics of the future. It has not the simplicity and the inevitableness of the very greatest work; it would be greater if it were less strange. One gift it has which no one can deny, profound and invincible originality. He would probably have been a greater mathematician if he had been caught and tamed a little in his youth; he would have discovered more that was new, and that, no doubt, of greater importance. On the other hand he would have been less of a Ramanujan, and more of a European professor, and the loss might have been greater than the gain."

NOTE: This sketch borrows with obvious freedom from *Collected Papers of Srinivasa Ramanujan*, Edited by G. H. Hardy, P. V. Seshu Aiyar, and B. M. Wilson. Cambridge University Press 1927. Any attempt to paraphrase the eloquence of their recitation would border on ridiculous vanity! JSM

EDUCATION CONFERENCE FOR SCIENCE TEACHERS AT BALL STATE TEACHERS COLLEGE

The Twenty-ninth Conference on the Education of Teachers in Science is to be held on the Ball State Teachers College campus in Muncie, Indiana on November 8, 9 and 10 (Thursday through Saturday), 1951.

This program will have such speakers as S. R. Powers, Professor of Natural Sciences, Columbia University; Glenn Blough and Paul Blackwood, Science Specialists of the United States Office of Education; Mr. Joe Craw, Superintendent of New Castle, Indiana, Schools; W. P. Allyn, Professor of Zoology, Indiana State Teachers College; E. Laurence Palmer, Professor of Nature and Science Education, Cornell University; and others of wide science experience. Robert H. Cooper, Head of the Science Department, Ball State Teachers College, is president at this time. Rose Lammel of New York University is first vice-president.

MAGNETIC FLUIDS FINDING NEW APPLICATIONS

New uses for the magnetic fluid used in clutches and brakes, announced by the National Bureau of Standards in 1948, were described to the American Institute of Electrical Engineers by Dwight B. Brede of the University of California division of electrical engineering.

He reported on investigations made by him concerning the use of a magnetic fluid. This fluid is a mixture of finely divided iron and oil. It becomes practically a solid when it is between two steel plates as in an automobile clutch and the plates are made magnetic by use of an electric current. It then holds the plates in a unit. When the magnetizing current is cut the iron particles lose their magnetism and the mixture becomes a fluid again.

Several scientists in the country are making investigations to determine the best types of oil and of iron to use in magnetic fluids for various uses. Mr. Brede reported that a mixture of seven parts of a particular carbonyl with one part of a silicone oil provides a magnetic fluid of low residual torque and high magnetic fluid torque.

A magnetic fluid dynamometer is definitely feasible and can be a useful engineering tool, he said. A dynamometer is used to measure the torque of a machine in order to determine its power output. The smoothness of control and the possibility of simple water cooling made the use of a magnetic fluid dynamometer attractive, he said, particularly where lead tests on large motors are being made.

ENGLISH AND METRIC UNITS IN LABORATORY WORK

H. Clyde Krenerick
Milwaukee, Wis.

Fifty years ago we were told that in a comparatively short time the metric system would be adopted and universally used in the United States. We were told that it was the task of the schools to educate and prepare the coming generation for the acceptance and the use of the new system.

Our text books in mathematics and the laboratory sciences strongly emphasized the new system. Our apparatus companies designed its instruments for measurements, its balances, weights, micrometer calipers, its scales and rulers, almost entirely for metric units.

The fifty years have passed and nothing has been accomplished. The adoption of the system is less possible than ever before. The metric system will never be universally used in the United States. The country is so highly industrialized that the expense, the confusion, and the constant delay in the conversion of the units makes the adoption of the metric system prohibitive.

With such a future in prospect why should our laboratories in elementary science continue to be so impracticable and so unpedagogical as to stress units and ideas that over ninety-five percent of our students will never have occasion to use? It is interesting to test the concept that students have of a centimeter of distance, a gram of force, or a gram-centimeter of work. It is far more difficult to teach principles when the language (units used) is confusing.

Most laboratory instruments for fine measurements are calibrated in metric units. But a high degree of accuracy is not necessary for teaching elementary principles. With larger pieces or quantities less delicate instruments may be used. Density of wood and water expressed in pounds per cubic foot or ounces per cubic inch is far more practical than grams per cubic centimeter.

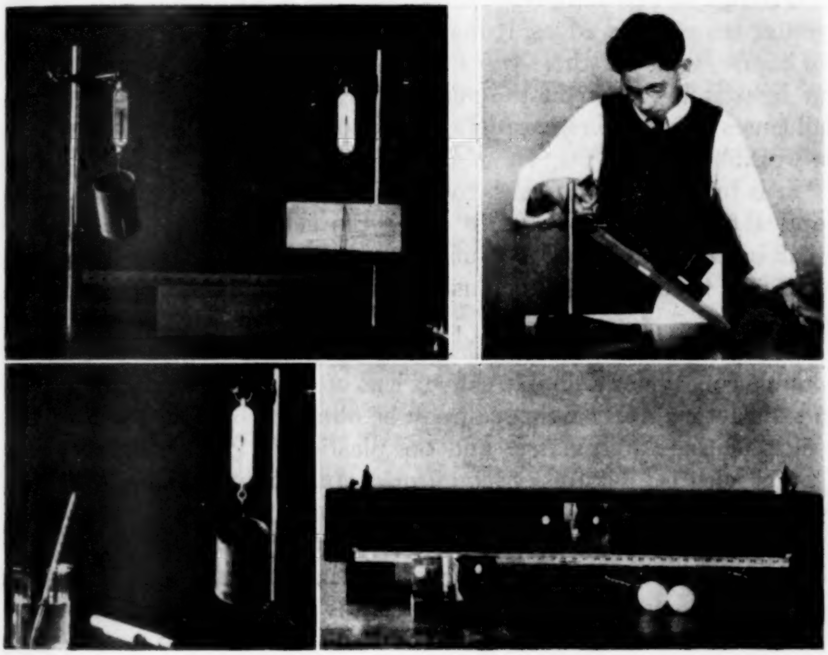
In simple machines it is better to measure the distances in feet and the forces in pounds so that the input and output will be expressed in common units—foot-pounds. In the inclined plane, if a four-pound mass on a block of wood is used in place of the carriage, highly acceptable results will be obtained if a 64-ounce capacity balance is used to measure the forces. With the block there is sufficient friction so that the efficiency will be found to increase as the grade is increased.

In the experiment with the photometer, if the distance from the lamps to the photometer is measured in feet, the illumination received on the two sides of the translucent surface may be expressed

in the practical unit, foot-candle. The experiment then serves a double purpose: Measurement of the candle power of lamp and the study, or application, of foot-candles of illumination.

In every day measurements of heat the unit used is the British thermal unit. If a container holding about a quart of water is used, the 64-ounce balance will give highly satisfactory results. A very interesting and instructive experiment is to mix about equal quantities of hot and cold water. Measure the heat given off by the hot water in B.t.u. and the heat received by the cold water in kilogram-calories. The relation between the two units may then be discovered.

The one great advantage of the metric system is its use of decimals in place of fractions. If our apparatus supply companies could be



induced to supply rulers with one edge calibrated in inches and tenths and the other edge calibrated in feet, tenths and hundredths, it would have the same advantage. The hundredths of an inch and the thousandths of a foot could be estimated with considerable accuracy.

The following method of reading the common English units directly in the decimal system has been used with great satisfaction by students and teachers: Read and record the number of full inches. For the decimal part of the next inch, read the number of full eighths and immediately express in hundredths. For the part of the next eighth, think of the division (1/8) as divided into six parts and esti-

mate the number of sixths to be added. Multiply this number by 2 to get the number of hundredths to be added to the hundredths already obtained. (The decimal equivalents for the seven eighths are quickly memorized.)

(Note: The experiments illustrated and described are taken from the manual and laboratory workbook, *Experiential Physics*, published by the author.)

"REVERSE ACTION" LENSES

FRANK HAWTHORNE AND LEE DUNBAR, JR.
Hofstra College, Hempstead, N. Y.

Physics students are frequently told that if a lens is thicker at the center than at the edges, it may be classified as converging. This is, of course, valid for those cases of a simple lens in which the velocity of light is less than in the surrounding medium. Since practically all lenses in common use satisfy this condition the statement provides a workable rule.

It is interesting, however, to speculate with one's students on the optical properties of a lens in which the velocity of light is greater than in the surrounding medium. After they have discussed the possibility, it is fairly easy to illustrate what actually happens in such cases.

Watch glasses may be sealed to a lucite ring to provide either a double concave or a double convex lens of air. It has been found that a satisfactory water-tight seal may be obtained by first warming the edges of the watch glasses and the plastic and cementing them together with De Khotinsky laboratory wax. Doubtless there are other methods which will also provide an adequate seal.

When such lenses are immersed in water, the double convex lens is diverging and, even more startling to the students, the double concave lens is converging. Thus, if a coin is placed on the bottom of a pail of water and viewed through the double concave lens (submerged) the coin appears larger while a similar use of the double convex lens makes it appear smaller. This "reverse action" can be shown clearly by placing each lens in turn in a rectangular aquarium full of water in which a few drops of fluorescein are dissolved. If a concentrated beam of light is directed through the lenses in an otherwise darkened room, the path of the light may be readily traced.

Such lenses have no apparent optical properties in air.

PLOT STUDIES IN HIGH SCHOOL BIOLOGY

H. SEYMOUR FOWLER
Assistant Professor of Science, Southern Oregon College of Education, Ashland, Ore.

There has been much said and written about the advantages of the use of living things as compared to the use of stuffed, dried, or pickled specimens in the teaching of high school biology. In addition one hears much in support of the contention that the proper place to study these living things is where one finds them in their natural setting. If these assumptions are valid, and we believe they are, then the following activities may be useful to the teacher of secondary school biology. Surface plot studies, the activity to which reference is made, certainly represents a means by which we may include the study of living things in their natural surroundings. These studies should become an important part of the high school biology program.

Large tracts of land remote from the school plant are not required. On the contrary, with the custodian's blessing, there is no better place than the school lawn on which to conduct your investigations. In this way the school lawn would become a functional part of the school property and not a thing to be gazed upon but not trod upon. If the authorities do not choose to react favorably to your request for a school lawn laboratory there is no need to forsake your plans. Any near-by field or vacant lot can serve equally as well.

Having chosen the location of your laboratory you then may begin work in earnest. Divide your class into teams composed of 2, 3, or 4 members per team. The number of individuals per team may be determined by the type and make-up of the class. If you are blessed with small classes, then a 2-member team is in order. Teams with more than 4 members are not advisable because of many reasons. First, this type of activity does not lend itself to large plot study groups because of the limited area on the plot. In the larger group it is easier for one individual to do all the work and derive all the benefits while the remainder of the group are satisfied to merely ride along. Also if numerous plots are being studied by many teams, smaller numbers of individuals in any single group make the total over-all problem of control less difficult for the teacher. This is a prime example of the exception to the rule of "safety in numbers." Any high school teacher who has conducted field trips will recognize the truth in the last statement. There are definite advantages gained from using, wherever possible, smaller groups for field experiences.

Each team is assigned or chooses an area in which to conduct its studies. It would be well to initiate the first phases of the work early in the school year. In this way the student is able to note the seasonal

changes on his plot. No one plot size is mandatory. Here again the teacher's judgement in the local situation is the deciding factor. Plots may be square, circular, or irregular in shape. However, for comparison of plots it might be well to choose a definite plot size and plot shape for use by all members of the class. In one case it was found that a square plot, $6' \times 6'$, was satisfactory. A photograph of this plot is shown as Figure 1.

Numerous meaningful activities can be conducted on each of the areas after the sites for the plots have been laid out. The students should first make maps of their plots. On these maps it would be well to show direction, prominent features and type of cover. If possible

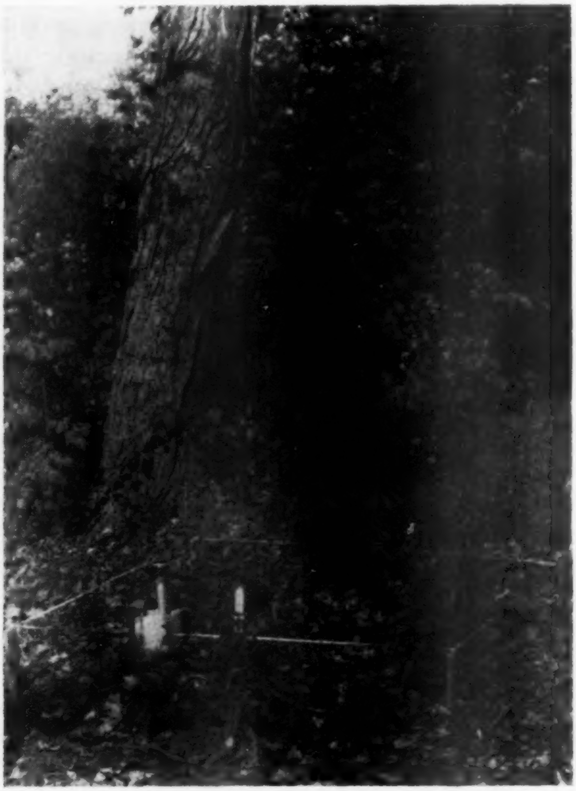


FIG. 1. An example of the square type of surface plot. This plot has the dimensions $6' \times 6'$.

one should identify the plants present and then mark their locations on the map. In addition the students should try to locate animals on the plot. It is not likely that vertebrates will be found in large numbers. However the study of the invertebrates present makes a

worthwhile activity and, without a doubt, these animals will be present in large numbers during some seasons.

Along with the studies of flora and fauna on the plot, it would be beneficial to conduct certain physico-chemical tests. Temperatures can be recorded with inexpensive thermometers. If the various plots under observation are located under different types of cover a comparison of temperatures on the various plots would be in order. The same holds true if the plots are located on slopes which face in different directions.

The amount of rainfall can also be determined. If commercial rain gauges are available the students could use these. However it is not essential that the gauges be of the commercial type. Since numerous types of improvised rain gauges can be devised, it would seem even better to have the students construct their own instruments. One type of rain gauge which has proven satisfactory can be seen on the plot pictured in Figure 1. This rain gauge was constructed from paraffin, construction paper, a cork, and an inexpensive funnel. White construction paper with dimensions, 9″×12″, was used to form the tube of the rain gauge. Funnels available were 3″ in diameter. Therefore it was decided that it would be advisable to make the diameter of the collecting tube $1\frac{1}{2}$″. This gave a 2:1 relationship between the diameter of the funnel and the diameter of the tube. Area relationships are important in calibrating the tube. Since areas vary as the square of the diameters, the relationship here in point therefore is 4:1. Knowing this, it is then necessary to compute the volume of a column of water with the area equivalent to the larger open end of the funnel as its base and a height of 1″ and to find the height of this column of water using the cross-section area of the tube as its base. Since the relationship of the areas of the two bases is 4:1, the height of a column of water in the tube would be four times the height of an equal volume of water collected at the open end of the funnel. This made the gauge calibration a simple matter. A vertical distance of 4″ on the tube was therefore equivalent to 1″ of rainfall at the opening of the funnel.

Since the desired diameter of the tube was $1\frac{1}{2}$″, it became necessary to find the circumference of a circle with such a diameter. This diameter, using π equal to 3.1416 was 4.71240″. With further experimentation in making the tubes it was found that by using an initial circumference of 4.75″ it was possible to arrive at a final circumference of 4.71″ after the tube had been dipped in melted paraffin.

The following method was used in constructing the tube. A line was drawn on the construction paper $4\frac{3}{4}$″ from the edge of the paper. A second line parallel to the first was drawn $5\frac{3}{4}$″ from the edge of the paper. These two lines formed the boundaries for the calibration of

the tube. The paper was then cut along the line located at a distance of $5\frac{3}{4}''$. The scale of the rain gauge was marked on the paper in pencil, beginning with the zero calibration which was located $\frac{1}{2}''$ from the base. It was planned to sink the finished tube in paraffin to a depth of $\frac{1}{2}''$; thus the zero calibration was marked in as a guide line. From this guide line to the opposite edge of the paper, lines were drawn at each $1''$ interval. Each of these lines was parallel to the zero cali-

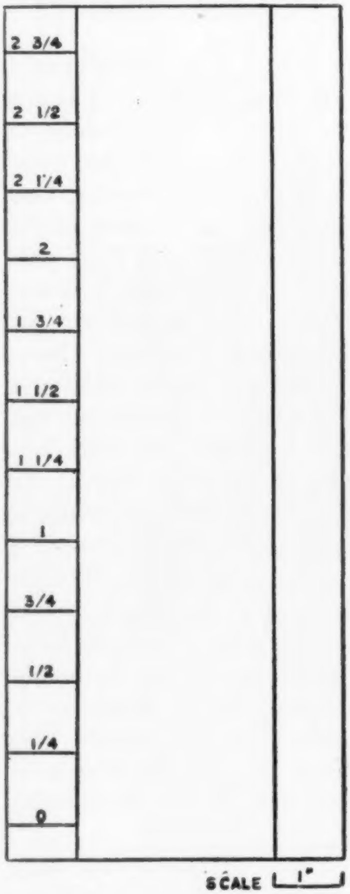


FIG. 2. Pattern for construction of tube of rain gauge.

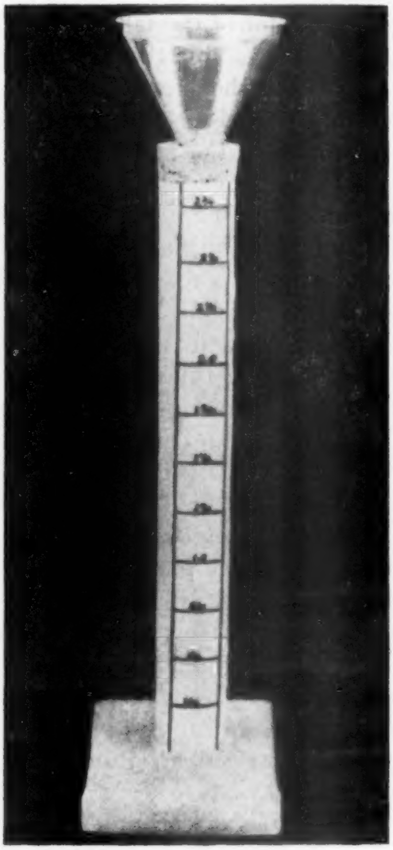


FIG. 3. Rain gauge for use in plot studies.

bration line. The area of the calibration was to act as a seal in forming the tube. Therefore a line was drawn $1''$ from the edge opposite the side of the calibration (for pattern used in making the tube of the rain gauge, see Figure 2). Next the area enclosed by the last mentioned line and the edge of the paper was covered with rubber cement. The area on the reverse side of the calibration column was

also cemented. These two areas were brought together using the line 1″ from the edge as a guide. After the rubber cement had dried, the tude was dipped in melted paraffin. This dipping process was then repeated.

The next step in the construction of the gauge was concerned with the building of a form for holding the melted paraffin which was to be used in preparing the base. A paper box was made in a manner similar to that used in microtome sectioning. Its dimensions were: length, 4″; width, 4″; and height, 1½″. Next melted paraffin was poured into the box to a depth of 1″. The tube was lowered into the paraffin, centered and held in place with a ringstand and clamp. If ringstands and clamps are not available, a substitute method can be employed. A layer of paraffin can be placed in the box to a depth of ½″. After the paraffin has solidified the tube is then put in place and

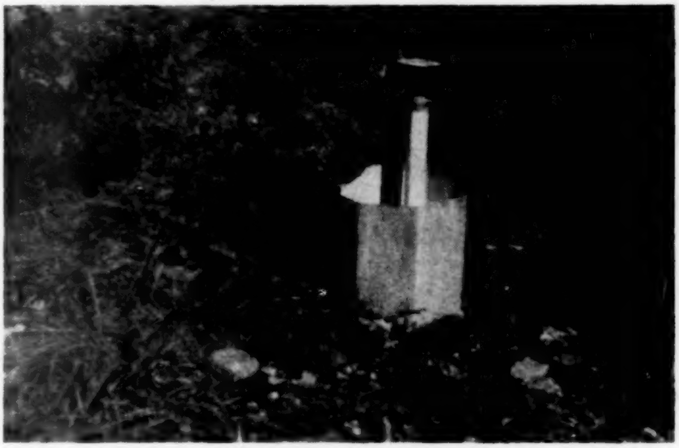


FIG. 4. Rain gauge set up in field. Note protective shield made of 28 gauge galvanized iron.

additional layers of paraffin can be added to produce the desired depth. In either case it is important to observe rather carefully the hardening of the paraffin so that the tube may be lowered to a depth equivalent to the line of the zero calibration and so that it will remain in place when the paraffin has solidified.

The small opening of the funnel is then used as a cork borer to make the hole in the cork. Cork remaining in the funnel can be removed with a nail or small stick. When the funnel spout has passed through the cork and is in place, it is only necessary to insert the cork into the tube of the rain gauge and the rain gauge is ready for use. (For photograph of rain gauge, see Figure 3.)

To increase stability and to guard against upsetting the rain gauge in the field, an additional precaution should be taken. Guards should

be put around each rain gauge. In the particular case described here, the guards consisted of rectangular strips of 28 gauge galvanized sheet iron which was about 10″ wide. These strips were bent into a circle (open cylinder) and driven into the ground to a depth of approximately 1″. (See Figure 4.) The rain gauge was then put in place inside this guard.

The compactness of the soil on the plots should also be determined. A device used to measure soil compactness was constructed in the following manner. This device employs the principle of the pile driver in its operation. The base of the tester was made from two pieces of $2''\times4''$ lumber fastened together. The completed base had the dimensions: width, $3\frac{1}{2}''$; length, $3\frac{1}{2}''$; and height, $3\frac{1}{4}''$. The frame of the tester was made by fastening to each corner, of the base a piece of wood $\frac{1}{2}''\times\frac{1}{2}''\times33''$. Screws were used to fasten the four corner strips to the base. To complete the four corners; strips with dimensions $\frac{1}{8}''\times1''\times33''$ were used. Each of these strips were nailed in place along and adjacent to the larger corner strips. The dropping block was constructed with two pieces of $2''\times4''$ lumber. Its dimensions were: length, $3\frac{1}{4}''$; width, $3\frac{1}{4}''$; height, $3\frac{1}{2}''$. The lower horizontal surface of this block was covered with a piece of 28 gauge galvanized iron. The galvanized iron was nailed to the dropping block. The dropping block was then put in place within the four corners of the tester. Two $\frac{1}{2}''\times\frac{1}{2}''\times4\frac{1}{2}''$ sticks and two sticks $\frac{1}{8}''\times\frac{1}{2}''\times3\frac{3}{4}''$ were attached to the upper end of the tester. These four pieces held the four corners rigidly so that the four long sides of the tester acted as tracks within which the dropping block would fall vertically. The dropping block could then be lifted to the top of the frame and released. It then would fall freely the distance to the base.

A vertical hole was then made in the center of the base. The diameter of this hole was such that an 8″ spike with a diameter of $\frac{3}{8}''$ moved through it freely. The 8″ spike was used to penetrate the soil. This spike was marked in $\frac{1}{2}''$ calibrations through a distance of 5″ on the spike and the calibrations were numbered from 1 through 10. Calibration #10 was at the head end of the spike. (For photograph of soil compactness tester, see Figure 5.)

To operate the soil compactness tester, the device is put in place on the surface of the soil to be tested. The spike then rests against the surface of the soil. The calibration on a level with the upper surface of the base is read and recorded. The tester is held in its vertical position with the user's left hand while the right hand is used to lift the dropping block to a maximum height within the frame. The dropping block is released and falls freely striking the head of the spike. The calibration at the level with the upper surface of the block is read and recorded. The distance of penetration per fall can

be determined by subtracting the reading on the spike before the block has fallen from the reading on the spike after the block has dropped. If the soil is of such a nature that one drop causes a penetration of less than one calibration, $\frac{1}{2}''$, it seems advisable to use a larger number of impacts before calculating the total penetration. In fact before the compactness of soils in different locations was compared it would be well to determine the average depth of penetration per impact in the different locations. In this way the proper number of impacts to be used for comparison of the soils could be determined.

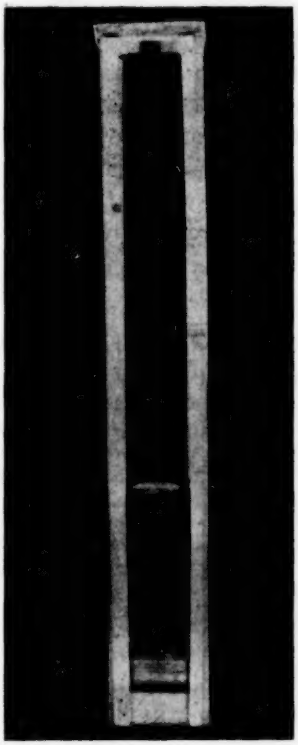


FIG. 5. Soil compactness tester.

The students might also determine the rate of water penetration into the soil of their plots. In one case, tin cans, such as those in which citrus fruit juices are sold, were used for this purpose. Both ends of these #3 cans were removed. One of the ends was removed in such a way that a sharp cutting edge was left on the can. The sharp edge of the can was placed against the soil. Pressure was applied to the can with the hand, using a twisting motion so that the can's lower edge cut into the soil. This pressure and twisting motion was continued until the can had penetrated into the soil to a depth of 1". The can was then filled with water. The time for this volume of

water to penetrate the soil was then recorded. This test should be repeated in five different locations on the plot. After collecting these data an average rate of water penetration should be determined.

It would then be well to ask the students if any relationship existed between the compactness of the soil as determined with the soil compactness tester and the rate of water penetration. This question could be answered if the students compared the results of their various tests.

These are only a few of the possible interesting activities which may be carried out with plot studies. The resourceful teacher will be able to devise many more. There is much to be gained by utilizing plot studies over the year as an integral part of your biology program. Many of the principles and concepts which are usually presented from the text can be demonstrated on the plot. But, perhaps the most important advantage gained is the opportunity to use living things in their natural surroundings where they react in their own normal manners. Where then, is there a better place to observe life which is the very essence of biology?

CONCRETE MADE NOW WITH CORNCOBS OR AIR

Farmers who want a lightweight concrete for farm buildings can now utilize in making it either one or two plentiful farm materials—corncobs or air.

Both types of concrete are being made, the U. S. Department of Agriculture reports, but much work must be done before they are ready for general use. The first uses corncob pellets as filler or aggregate, the second is filled with bubbles of air.

The corncob concrete is being developed at the Michigan State College, East Lansing, in cooperation with the federal department. The pellets used are about three-eighths of an inch in diameter and replace ordinary aggregate. Before mixing with the cement, water and sand, the corncob pellets are soaked in water for hours. Otherwise they will absorb the water in the mix and cause the concrete to rupture in setting.

An improved air-containing concrete, suitable for farm use, has been developed by the National Bureau of Standards. Officially it is called air-gravel concrete. Gravel is used as the aggregate, but air replaces all or part of the sand. The air bubbles, created in the mix by the use of chemicals called air-entraining agents, makes the mixture workable and gives to the set concrete lightness and high insulating properties because of the millions of tiny air cells it contains.

Table-viewer for photographic slides is plugged into the household current and can be used in broad daylight or in a brightly lighted room. Transparencies inserted in it give pictures four times the size of the slide on a screen near its top. Colored slides are reproduced vividly.

Lamp for the telephone that automatically turns on when the telephone bell rings has just received a patent. Sound waves from the bell actuate the switch that turns on the electricity. It is particularly for use at night to aid in reaching a ringing phone.

CONVENTION PROGRAM

Central Association of Science and Mathematics Teachers
November 22–24, 1951

Headquarters: Hollenden Hotel, Cleveland, Ohio

Registration: Mezzanine, 5–8 P.M. Thursday and beginning at 8 A.M. Friday.

Friday Morning, November 23

General Session
Ball Room, 9:30–10:30 A.M.

Opening General Session

Presiding: Donald W. Lentz, President

Welcome to Cleveland!
Dr. Mark C. Schinnerer, Superintendent of Schools, Cleveland, Ohio.

Recognition of Student Exhibitors
John R. Habat, Euclid Shore Jr. High School, Euclid, Ohio.

Education—The Primary Atomic Control
Dr. Donald H. Loughridge, Assistant Director, Reactor Development Division, Atomic Energy Commission.

SECTION MEETINGS

Friday Morning

Mathematics Section
Ball Room, 10:40–12:30

Presiding: Enoch D. Burton, Shortridge High School, Indianapolis, Indiana.

Developing Appreciation of Elementary Mathematics
Professor Howard Fehr, Head of the Department of the Teaching of Mathematics, Columbia University.

Chemistry Section
Parlor C, 10:40–12:30

Presiding: Gerald Osborne, Western Michigan College of Education, Kalamazoo, Michigan.

Application of Ultrasonics in Chemistry
Dr. Ernest B. Yeager, Technical Director, Ultrasonic Research Laboratory, Western Reserve University, Cleveland, Ohio

The Use of Models in Presenting Elementary Chemistry
Dr. J. A. Campbell, Severance Chemical Laboratory, Oberlin College, Oberlin, Ohio

Biology Section
Parlors A-B, 10:40–12:30

Presiding: Frances M. Gourley, LaPorte High School, LaPorte, Indiana.

Making Genetics Interesting for High School Biology Students.
Dr. Richard Armacost, Department of Biology, Purdue University, Lafayette, Indiana.

A Botanist in the Andes
A color-movie visit to the Andes. Dr. Harry J. Fuller, Department of Botany, University of Illinois, Urbana, Illinois

ELEMENTARY SCIENCE SECTION
Room 284, 10:40–12:30

PRESIDING: Albert Piltz, Roosevelt Elementary School, Detroit, Michigan.

Teaching Science Generalization
Dr. Wilbur Beauchamp, Associate Professor of Education, University of Chicago, Chicago, Illinois.

Friday Afternoon

GENERAL SESSION
Ball Room, 1:30–2:35

PRESIDING: Philip Peak, Vice President

Science and International Understanding
Dr. Elvin C. Stakman, Chief of the Division of Plant Pathology and Botany, University of Minnesota, Minneapolis, Minnesota.

Report on Policy Projects of the Association
Philip Peak, Coordinator, Indiana University, Bloomington, Indiana.

SECTION MEETINGS

Friday Afternoon

ELEMENTARY MATHEMATICS SECTION
Parlor C, 2:40–4:30

PRESIDING: Dr. Ella Marth, Harris Teachers College, St. Louis, Missouri.

A Pictorial Visit to the Elementary Mathematics Classroom
Dr. Herschel Grime, Supervisor of Mathematics, Cleveland Public Schools.

Using the Radio to Teach Arithmetic
Marcella McNerney, Principal, Arithmetic Curriculum Center, East Clark School, Cleveland, Ohio.

GENERAL SCIENCE SECTION
Parlors A-B, 2:40–4:30

PRESIDING: Fred W. Fox, McGuffey High School, Miami University, Oxford, Ohio.

Photography as a Teaching Tool and Student Activity in General Science
Herbert P. McConnell, Assistant Professor of Integrated Studies, School of Education, Miami University, Oxford, Ohio.

The Use of Laboratory Activities in Teaching General Science
Dr. Milton O. Pella, Assistant Professor of Education and Teacher of Science, College of Education, University of Wisconsin, Madison, Wisconsin.

Ohio's School-Forest Program—Outdoor Laboratories For Conservation Education
Dr. Carl S. Johnson, Assistant Professor of Conservation, Ohio State University, Columbus, Ohio.

PHYSICS SECTION
Ball Room, 2:40–4:30

PRESIDING: Delia Redman, New Haven High School, New Haven, Indiana.

Part I—Physics for Today
A demonstration of the principles and applications of the gyroscope. William J. Dooley, Aeronautical Sales Engineer, Sperry Gyroscope Company, Cleveland, Ohio.

Part II—Current Materials for Teaching Science

CHAIRMAN: John S. Richardson, Associate Professor of Education, Ohio State University, Columbus, Ohio.

1. **Show Them How and Why It Works: Materials from Industry for the Classroom**

R. D. Stanton, Educational Service Division, General Electric Company.

2. **Make Them Want to Learn: The Science Magazine In The Classroom**
Hartley E. Lowe, Assistant Managing Editor, *Popular Science Monthly*.
3. **Organizing Current Materials for Effective Use**
Gordon E. Vars, Core Teacher, Audio-Visual Coordinator, Bel Air High School, Bel Air, Maryland.
4. **Use of Current Materials**
Dr. Ralph W. Lefler, Assistant Professor of Physics and Education, Purdue University, Lafayette, Indiana.

PICTURES OF FIELD TRIPS
Room 284, 4:30–5:30

The Cleveland Regional Council of Science Teachers invites all Central Association members and guests to attend a showing of pictures pertaining to recent field trips and convention activities of the Council.

Friday Evening

ANNUAL BANQUET
Ball Room 6:30 P.M.
(Informal)

CHAIRMAN IN CHARGE OF ARRANGEMENTS: Ona Kraft, Collinwood High School, Cleveland, Ohio.
TOASTMASTER: Arthur O. Baker, Supervisor of Science, Cleveland Public Schools.

The Next Fifty Years in Science
Dr. David Dietz, Science Editor, Scripps-Howard Newspapers, and Lecturer in General Science, Western Reserve University, Cleveland, Ohio.

MIXER
Parlors A-B-C, 9:30 P.M.

CHAIRMAN: Abbie Rush, Lakewood High School, Lakewood, Ohio.
A social event designed for fun and relaxation.

Saturday Morning, November 24

GENERAL SESSIONS
BUSINESS MEETING
Parlors A-B-C, 8:30–9:15 A.M.

PRESIDING: Donald W. Lentz, President.

GENERAL MEETING
Ball Room, 9:30–10:30

PRESIDING: Allen F. Meyer, Past President.

Foundations, Industry, and Education
Vice Admiral Harold G. Bowen, U.S.N. (Ret.), Executive Director, Thomas Alva Edison Foundation, West Orange, New Jersey.

Presentation of Emeritus Memberships
James C. Adell, Board of Education, Cleveland, Ohio.

Saturday Morning, November 24

GROUP PROGRAMS

ELEMENTARY SCHOOL GROUP
Parlor C, 10:40–12:30

PRESIDING: Dr. Charlotte W. Junge, Wayne University, Detroit, Michigan.

Helping Children "Discover" Arithmetic
(Presentation of a new teaching film in arithmetic)
Dr. Chester McCormick, Assistant Professor of Education, Wayne University, Detroit, Michigan.

Utilizing the Bulletin Board in Teaching Elementary Science
Frank Yonkstetter, Barton Elementary School, Detroit, Michigan.

JUNIOR HIGH SCHOOL GROUP
Parlors A-B, 10:40–12:30

PRESIDING: Dr. Ella Marth, Harris Teachers College, St. Louis, Missouri.

Problem Solving in Junior High School Mathematics
Eugene P. Smith, Instructor in Mathematics, University School, Ohio State University, Columbus, Ohio.

Some Problems of Vocabulary and Reading Difficulty in Teaching Junior High School Science
Dr. George G. Mallinson, Professor of Psychology and Education, Western Michigan College of Education, Kalamazoo, Michigan.

SENIOR HIGH SCHOOL GROUP
Room 284, 10:40–12:30

PRESIDING: Dr. Ira C. Davis, University of Wisconsin, Madison, Wisconsin.

Providing A Challenging Program in Mathematics and Science for Pupils of Superior Mental Ability—(a panel discussion)
Ona Kraft, Head of the Mathematics Department, Collinwood High School, Cleveland, Ohio.
James W. Gebhart, Chairman of the Science Department, Euclid High School, Euclid, Ohio.
Eugene F. Peckman, Senior Supervisor, Section on Science and Mathematics, Pittsburgh Public Schools
Dr. Harry Cunningham, Chairman of the Department of Biology, Kent State University, Kent, Ohio.

JUNIOR COLLEGE GROUP
Parlor D, 10:40–12:30

PRESIDING: Luther Shetler, Bluffton College, Bluffton, Ohio.

How Can We Improve Our Beginning Courses?

The Merits and Content of a Freshman Mathematics Course Combining College Algebra, Trigonometry, and Analytic Geometry.
Dr. F. Lynwood Wren, Professor of Mathematics George Peabody College for Teachers, Nashville, Tennessee.

How Should Modern Physics Be Handled in a General Physics Course?
Richard Weaver, Assistant Professor of Physics, Bluffton College, Bluffton, Ohio.

CONSERVATION GROUP
Ball Room, 10:40–12:30

PRESIDING: Robert Finlay, John Marshall High School, Cleveland, Ohio.

Conservation—The Foundation of a Permanent Economy
Louis Bromfield, Malabar Farm, Lucas, Ohio.

Saturday Afternoon, November 24

ASSOCIATION-SPONSORED TRIPS
Leave: 1:30 P.M.

Trip 1. A tour through cultural and educational centers of Cleveland, highlighted by a visit to the grounds of famous Nela Park, home of the G. E. Lighting Institute, and a stop at one of Cleveland's Science Museums.
Trip 2. A tour through one of Cleveland's fabulous industrial plants.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Missouri

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

Late Solutions

2235, 45. *C. W. Trigg, Los Angeles.*

2251. *Proposed by R. E. Horton, Los Angeles City College.*

Find the points on the curve $y^2=2x^3$ whose powers with respect to the circles c_1: $x^2+2x+y^2=0$ and c_2: $x^2-4x+y^2=0$ are in the ratio $p_1=2p_2$.

Solution by V. C. Bailey, Evansville, Indiana

The power of a point outside a circle equals the square of the length of the tangent from the point to the circle.

The square of the length of a tangent from the point (x_1, y_1) to a circle

$$Ax^2+By^2+Dx+Ey+F=0,$$

is

$$Ax_1^2+By_1^2+Dx_1+Ey_1+F.$$

The problem now reduces to that of finding a point, (x_1, y_1) on the curve $y_1^2=x_1^3$, such that the square of the length of the tangent from (x_1, y_1) to c_1 equals twice the square of the length of the tangent from (x_1, y_1) to c_2.

That is,

$$x_1^2+2x_1+y_1^2=2(x_1^2-4x_1+y_1^2) \tag{1}$$

$$x_1^2+y_1^2-10x_1=0. \tag{2}$$

Solve simultaneously (2) and

$$y_1^2=2x_1^3. \tag{3}$$

Then

$$x=0,\ 2,\quad 2.$$

$$y=0,\ 4,\ -4.$$

Solutions were also offered by C. W. Trigg, Los Angeles City College; Robert E. Horton, Los Angeles; Charles McCracken, Jr., University of Cincinnati.

2252. *Proposed by Norman Anning, University of Michigan.*

The curves $\sqrt{x}=\sqrt{y}+1$, $\sqrt{x}+\sqrt{y}=1$ and $y=\sqrt{x}+1$ are parts of the parabola: $x^2-2xy+y^2-2x-2y+1=0$. $y=4\sqrt{x}$, $y=-4\sqrt{x}$ are parts of $y^2=16x$. Find points of intersection of the whole curves.

Solution by V. C. Bailey, Evansville, Ind.

Making the substitution $y^2=16x$ in the equation of the first parabola we get

$$x^2-8x\sqrt{x}+14x-8\sqrt{x}+1=0.$$

Let

$$X=\sqrt{x}$$

$$X^4-8X^3+14X^2-8X+1=0$$

$$X=1 \text{ (double root) } X=3+2\sqrt{2},\quad X=3-2\sqrt{2} \text{ (extraneous)}.$$

So there are two points of intersection, namely

$$(1,4) \quad\text{and}\quad (\{3+2\sqrt{2}\}^2, 4\{3+2\sqrt{2}\}).$$

Editors Note: This problem was not completely given in the magazine.

2253. *Proposed by Norman Anning, University of Michigan, Ann Arbor, Michigan.*

The curves $\sqrt{y}=\sqrt{x}+1$ and $y=4\sqrt{x}$ are parts of two parabolas, what points, if any, do they have in common?

Solution by Clinton Jones, Student, University of Michigan

Let $\sqrt{y}=\sqrt{x}+1$ be equation (1) and $y=4\sqrt{x}$ be equation (2), substituting the value of the $\sqrt{x}$ from (2) into equation (1), one gets

$$\sqrt{y}=\frac{y}{4}+1$$

or

$$y^2-8y+16=0.$$

Solving for y, one finds $y=4$, 4
Substituting in (2) one finds $x=1$, 1
But the point (1, 4) is not the only point the parabolas have in common.
Squaring (1), one obtains,

$$x^2+y^2-2xy-2x-2y+1=0. \tag{3}$$

Squaring (2), one gets,

$$y^2=16x. \tag{4}$$

Now, substituting the values of x and x^2 from (4) into equation (3), one gets,

$$y^4-32y^3+224y^2-512y+256=0.$$

The roots of this equation are:

$$y=4,\ 4,\ (12+8\sqrt{2}),\ (12-8\sqrt{2}) \quad\text{or}\quad y=4,\ 4,\ (23.312),\ (0.688).$$

Substituting these values into equation (4), one finds, $x=1$, 1, $(17+12\sqrt{2})$, $(17-12\sqrt{2})$.
The common points of the whole curves are therefore:

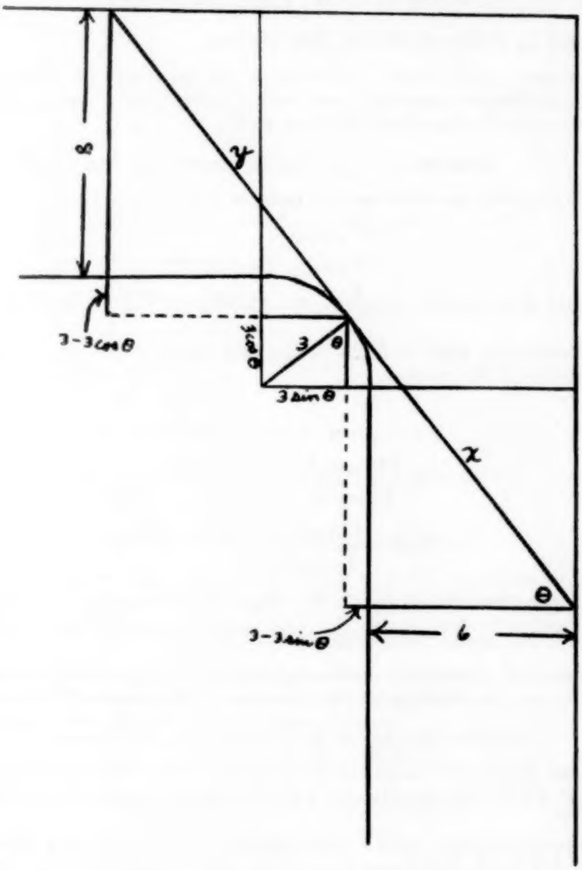
$$(1,4);\ [(17+12\sqrt{2}),\ (12+8\sqrt{2})];\ [(17-12\sqrt{2}),\ (12-8\sqrt{2})].$$

Solutions were also offered by: Charles McCracken, Jr., and Dewey Blair, Cincinnati; Austin Koehler, Mt. Pleasant, Iowa.; C. W. Trigg; and V. C. Bailey, Evansville, Ind.; Leon Bankoff, Los Angeles.

2254. *Proposed by V. C. Bailey, Evansville, Ind.*

Two corridors, widths 6 ft. and 8 ft. respectively, intersect at right angles. If the inside corner is rounded so as to form a quadrant of a circle with radius 3 ft., find the length of the longest thin rod which can be moved in a horizontal position from one corridor to the other.

Solution by Louis F. Scholl, Buffalo



$$\cos\theta=\frac{9-3\sin\theta}{x}\qquad\qquad \sin\theta=\frac{11-3\cos\theta}{y}$$

$$x+y=\frac{9-3\sin\theta}{\cos\theta}+\frac{11-3\cos\theta}{\sin\theta}\tag{1}$$

$$\frac{d(x+y)}{d\theta}=9\sec\theta\tan\theta-3\sec^2\theta-11\csc\theta\cot\theta+3\csc^2\theta=0$$

$$\frac{9\sin\theta}{1-\sin^2\theta}-\frac{3}{1-\sin^2\theta}+\frac{3}{\sin^2\theta}=\frac{11\sqrt{1-\sin^2\theta}}{\sin^2\theta}\,.$$

Let $\sin\theta = s$, square both members and simplify:

$$202s^6 - 108s^5 - 327s^4 + 54s^3 + 327s^2 - 112 = 0.$$

Solving,

$$s = \sin\theta = 0.73936$$
$$\cos\theta = 0.67332.$$

Substituting these values in (1), we get

$$x + y = 22.218 \text{ feet.}$$

A solution was also offered by C. W. Trigg, Los Angeles.

2255. *Proposed by Julius S. Miller, New Orleans.*

A man throws a stone with a velocity V_1 at an angle of elevation, A. In t seconds later, he throws a second stone with a velocity of V_2 at an angle of elevation, B. If the second stone hits the first, find t.

Solution by V. C. Bailey, Evansville, Ind.

Let the parametric equations of the path of a projectile be

$$x = V_0 \cos\phi \cdot T$$
$$y = V_0 \sin\phi \cdot T - 1/2gT^2.$$

If the second stone strikes the first, their abscissas will be equal at the time of contact.

Let T represent the time of flight of the first stone and then $(T-t)$ represents the time of flight of the second.

Now

$$x = V_1 \cos A \cdot T = V_2 \cos B \cdot (T-t)$$

$$T - t = \frac{TV_1 \cos A}{V_2 \cos B}$$

$$t = T - \frac{TV_1 \cos A}{V_2 \cos B}.$$

A solution was also offered by C. W. Trigg.

2256. *Proposed by Lanier Strong, Kirksville, Mo.*

Find by means of elementary geometry a point in a plane such that the sum of its distances from two fixed points on one side of the plane shall be a minimum.

Solution by Charles McCracken, Jr., Cincinnati

The required point will lie on the intersection XY of the given plane and the plane through A and B perpendicular to it. We now consider the plane containing A, B, and XY.

Draw AO perpendicular to XY and produce it to A', so that $OA' = OA$. Join $A'B$, cutting XY in P. Take any point Q in XY. Joint AP, AQ, $A'Q$.

In triangles AOP, $A'OP$; $AO = A'O$, $OP = OP$, and $\measuredangle AOP = \measuredangle A'OP$.

$$AP = A'P.$$

Similarly

$$AQ = A'Q..$$
$$\measuredangle APX = \measuredangle A'PO = \measuredangle BPY$$
$$AQ + QB = A'Q + QB.$$

Similarly

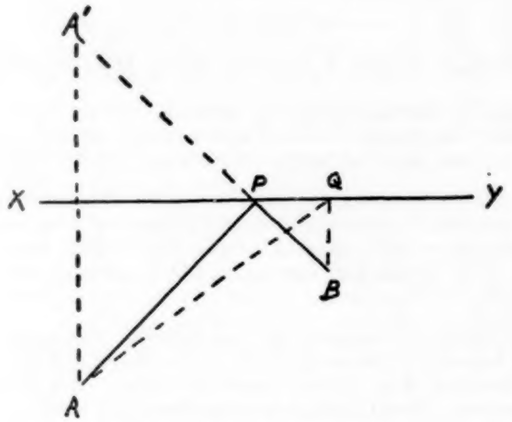
$$AP + PB = A'P + PB$$
$$AP + PB = A'B.$$

But if Q does not coincide with P

$$A'Q+QB>A'B$$
$$AQ+QB>AP+PB.$$

Thus we see that the required point is the point P such that $\measuredangle APX=\measuredangle BPY$.

The plane geometry part of this proof appears as a theorem in ***The Harpur Euclid, an Edition of Euclid's Elements***, by Langley and Phillips, Longmans, Green, and Co. 1906. The above proof is taken directly, verbatim from this book. This appears in this book on pages 468–469.



A and B are the given points.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

Kathleen Hamlin, Detroit.

PROBLEMS FOR SOLUTION

2269. *Proposed by Howard D. Grossman, New York.*

A circle of radius 15 intersects another circle, radius 20 at right angles. What is the difference of areas of non-overlapping portions?

2270. *Proposed by V. C. Bailey, Evansville, Indiana.*

Show that $\pi/4=\arctan 1/2+\arctan 1/5+\arctan 1/8$

2271. *Proposed by V. C. Bailey, Evansville, Indiana.*

Solve the equation: $64 \sin 7\theta+\sin 7\theta=0$.

2272. *Proposed by V. C. Bailey, Evansville, Indiana.*

Prove: $\text{Tan }(3\pi/11)+4 \sin (2\pi/11)=\sqrt{11}$.

2273. *Proposed by Alan Wayne, Flushing, N. Y.*

Let points D, E, and F be taken on the sides AB, BC and CA, respectively, of triangle ABC so that $AD/DB=r$, $BE/EC=s$ and $CF/FA=t$. If AE and CD intersect in P, BF and AE intersect in Q, and CD and BF intersect in R, express the ratio of the area of triangle PQR to the area of triangle ABC as a function of r, s and t.

2274. *Proposed by Alan Wayne, Flushing, N. Y.*

Let AB and BC be adjacent sides of a regular polygon whose center is O and whose interior angle is θ. Segments AO and BC are extended (if necessary) to meet in point P, show that $PC/BP=2\cos\theta$.

BOOKS AND PAMPHLETS RECEIVED

THE TEACHING OF MATHEMATICS, by David R. Davis, Ph.D., *State Teachers College, Montclair, New Jersey.* Cloth. Pages xv+415. 14×21.5 cm. 1951. Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass. Price $4.50.

A FIRST COURSE IN ALGEBRA, Second Edition, by Walter W. Hart, *Author of Mathematics Textbooks, Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin, Madison, Wis.* Cloth. Pages ix+389. 13.5 ×21 cm. 1951. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.28.

A SECOND COURSE IN ALGEBRA, Second Edition, Enlarged, by Walter W. Hart, *Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin, Madison, Wis.* Cloth. Pages viii+488. 13.5×21 cm. 1951. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.40.

ANALYTIC GEOMETRY AND CALCULUS, by William R. Longley, *Yale University;* Percy F. Smith, *Yale University;* and Wallace A. Wilson, *Late Professor of Mathematics, Yale University.* Cloth. Pages ix+578+xx. 15×23 cm. 1951. Ginn and Company, Statler Building, Boston 17, Mass. Price $5.00.

TRIGONOMETRY FOR TODAY, by Milton Brooks, *Instructor of Mathematics' Central High School, Philadelphia, Pennsylvania;* A. Clyde Schock, *Head of Department of Mathematics, Central High School, Philadelphia, Pennsylvania;* Consultant, Albert I. Oliver, Jr., *Assistant Professor of Education, University of Pennsylvania.* Cloth. Pages ix+203+102. 13.5×21 cm. 1951. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $2.96.

THE LOST PHARAOHS, THE ROMANCE OF EGYPTIAN ARCHAEOLOGY, by Leonard Cottrell. Cloth. 256 pages. 13.5×21.5 cm. 1951. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

A CONCISE HISTORY OF ASTRONOMY, by Peter Doig, F.R.A.S., *Editor, Journal of the British Astronomical Association.* Cloth. Pages xi+320. 14×21.5 cm. 1951. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

ANALYTISCHE GEOMETRIE, by Dr. Gerhard Engel. Cloth. Pages vii+239. 15×28 cm. Walter de Gruyter and Company, Berlin, Germany.

THE CALCULUS OF FINITE DIFFERENCES, by L. M. Milne-Thomson, *Professor of Mathematics in the Royal Naval College, Greenwich, Gresham Professor in Geometry.* Cloth. Pages xxiii+558. 13.5×21.5 cm. 1951. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $4.50.

INTERMEDIATE ALGEBRA, Second Edition, by Raymond W. Brink, Ph.D., *Professor of Mathematics, University of Minnesota.* Cloth. Pages xi+295. 13.5

×21.5 cm. 1951. Appleton-Century-Crofts, Inc., 35 West 32nd Street, New York 1, N. Y. Price $3.00.

College Algebra, Second Edition, by Raymond W. Brink, Ph.D., *Professor of Mathematics, University of Minnesota.* Cloth. Pages xvi+495. 13.5×21.5 cm. 1951. Appleton-Century-Crofts, Inc., 35 West 32nd Street, New York 1, N. Y. Price $3.75.

200 Miles Up—The Conquest of the Upper Air, by J. Gordon Vaeth, *Aeronautical Engineer, U. S. Navy Special Devices Center, Office of Naval Research.* Cloth. Pages xiii+207. 15×23 cm. 1951. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y. Price $4.50.

The Restless Universe, Second Revised Edition, by Max Born. Cloth. 315 pages. 15.5×23.5 cm. 1951. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $3.95.

Psychology and Its Bearing on Education, by C. W. Valentine, M.A., D.Phil., *Emeritus Professor of Education in the University of Birmingham.* Cloth. Pages xvi+674. 11.5×18.5 cm. 1951. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

Mathematics for Engineers, Third Edition, by Raymond W. Dull, *Late Consulting Engineer; Member, American Society of Mechanical Engineers, Western Society of Engineers,* and Revised and Edited by Richard Dull, *Engineer, Webster-Chicago Corporation; Member, Society of American Military Engineers, American Association of Engineers.* Cloth. Pages xix+822. 13.5×20.5 cm. 1951. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $7.50.

Embryology of the Viviparous Insects, by Harold R. Hagan, *Associate Professor of Biology, The City College of the College of the City of New York.* Cloth. Pages xiv+472. 15×23 cm. 1951. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y. Price $6.50.

The New Military and Naval Dictionary, Edited by Frank Gaynor. Cloth. Pages viii+295. 15×23 cm. 1951. Philosophical Library, Inc., 15 East 40th Street. New York 16, N. Y. Price $6.00.

The Radio Amateur's Handbook, Twenty-eighth Edition, Revised by the Headquarters Staff of the American Radio Relay League. Paper. 16.5×24.5 cm. 1951. The American Radio Relay League, West Hartford, Conn. Price $2.50.

You Among the Stars, by Herman and Nina Schneider. Paper. 60 pages. 20×24 cm. 1951. William R. Scott, Inc., Publisher, 8 West 13th Street, New York 11, N. Y.

Teaching Science to Children, by Julian Greenlee, Ed.D., *Associate Professor of Biology and Physics, Western Michigan College of Education, Kalamazoo, Michigan.* Paper. Pages x+57. 21×28 cm. 1951. Wm. C. Brown Company, Dubuque, Iowa. Price $1.50.

Inventories of Apparatus and Materials for Teaching Science. Volume I, Primary, Secondary and Vocational Schools. Paper. 92 pages. 15.5×24 cm. 1950. Publication No. 560. United Nations Educational, Scientific and Cultural Organization, 19 Avenue Kléber, Paris, France.

Inventories of Apparatus and Materials for Teaching Science. Volume III, Technical Colleges, Part 2, Physics and Chemical Engineering. Paper. 117 pages 15.5×24 cm. 1951. Publication No. 837. United Nations Educational, Scientific and Cultural Organization, 19 Avenue Kléber, Paris, France.

Workbook and Laboratory Manual with Tests to Accompany High

SCHOOL PHYSICS, by Oswald H. Blackwood, *Professor of Physics and Education, University of Pittsburgh;* Wilmer B. Herron, *Head of the Physics Department, Butler High School, Butler, Pennsylvania;* and William C. Kelly, *Assistant Professor of Physics, University of Pittsburgh.* Paper. Pages ix+277. 18.5×26 cm. 1951. Ginn and Company, Statler Building, Boston 17, Mass. Price $1.40.

LABORATORY EXPERIMENTS IN THE PHYSICAL SCIENCES, by Anton Postl, *Assistant Professor of Science, Oregon College of Education, Monmouth, Oregon.* Paper. 72 pages. 20.5×27.5 cm. 1951. Burgess Publishing Company, 426 South Sixth Street, Minneapolis 15, Minn. Price $1.50.

MATERIALS AND METHODS IN THE STUDY OF PROTOZOA, by Harold Kirby, *Professor of Zoology, University of California, Berkeley,* Paper. Pages x+72. 21×28 cm. 1950. University of California Press, Berkeley 4, Calif. Price $2.50.

THE RADIO AMATEUR'S LICENSE MANUAL, Published by the American Radio Relay League. Paper. 95 pages. 16.5×24.5 cm. 1951. The American Radio Relay League, West Hartford, Conn. Price 50 cents.

IDENTIFYING EDUCATIONAL NEEDS OF ADULTS, by Homer Kempfer, *Specialist General Adult and Post-High-School Education.* Circular No. 330. Pages vi+64. 20×26 cm. 1951. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 35 cents.

IMPROVING SCHOOL HOLDING POWER. Report of Representatives of School Systems in Cities of More than 200,000 Population. Circular No. 291. 86 pages. 19.5×26 cm. 1951. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 40 cents.

DEFENSE PROGRAMS OF SELECTED FEDERAL AGENCIES AFFECTING COLLEGES AND UNIVERSITIES. A Summary Report Prepared for the Committee on Defense Programs of the Board of Control for Southern Regional Education, by Margaret C. James, William J. McGlothlin, and Harry B. Williams. Paper. 56 pages. 15×23 cm. 1951. Board of Control for Southern Regional Education, 830 West Peachtree Street, N.W., Atlanta 3, Ga. Price 40 cents for Single Copies and 30 cents for Lots of Ten or More.

GENERAL EDUCATION BOARD ANNUAL REPORT, 1950. Paper. Pages ix+91. 14.5×22 cm. General Educational Board, 49 West 49th Street, New York, N. Y.

PROCEEDINGS OF THE FORTY-FOURTH ANNUAL MEETING OF LIFE INSURANCE ASSOCIATION OF AMERICA. Paper. 171 pages. 13.5×22 cm. December 7, 1950. Life Insurance Association of America, 488 Madison Avenue, New York 22, N. Y.

MEETING DEFENSE GOALS. Second Quarterly Report to the President by the Director of Defense Mobilization, Charles E. Wilson. Paper. Pages iv+48. 19.5×26 cm. July 1, 1951. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 30 cents.

EVALUATION AND ADJUSTMENT SERIES:

ANDERSON CHEMISTRY TEST, Form AM, by Kenneth E. Anderson, *School of Education, University of Kansas.* 7 pages. 22×28.5 cm. 1950. Manual of Directions.

DUNNING PHYSICS TEST, FORM AM, by Gordon M. Dunning, *State Teachers College, Indiana, Pennsylvania.* 7 pages. 22×28.5 cm. 1950. Manual of Directions.

NELSON BIOLOGY TEST, FORM AM, by Clarence H. Nelson, *Michigan State College.* 8 pages. 22×28.5 cm. 1950. Manual of Directions.

READ GENERAL SCIENCE TEST, FORM AM, by John G. Read, *School of Education, Boston University*. 7 pages. 22×28.5 cm. 1950. Manual of Directions.

DAVIS TEST OF FUNCTIONAL COMPETENCE IN MATHEMATICS, FORM AM, by David J. Davis, *Eastern Illinois State College*. 8 pages. 22×28.5 cm. 1950. Manual of Directions.

LANKTON FIRST-YEAR ALGEBRA TEST, FORM AM, by Robert Lankton, *Teachers College, Cedar Falls, Iowa*. 6 pages. 22×28.5 cm. 1950. Manual of Directions.

SHAYCOFT PLANE GEOMETRY TEST, FORM AM, by Marion F. Shaycoft, *National League of Nursing Education*. 6 pages. 22×28.5 cm. 1950. Manual of Directions.

SNADER GENERAL MATHEMATICS TEST, FORM AM, by Daniel W. Snader, *University of Illinois*. 7 pages. 22×28.5 cm. 1950. Manual of Directions. World Book Company, Yonkers 5, N. Y.

SCIENTIFIC PERSONNEL EMPLOYMENT BULLETIN. Pages vii+55. 20×26 cm. January 1951. Personnel Division, Office of Naval Research, Department of the Navy, Washington 25, D. C.

BALPHOT METALLOGRAPH Catalog E-232. 19 pages. 21.5×28 cm. Bausch and Lomb Optical Company, Rochester 2, N. Y.

WATER POLLUTION IN THE UNITED STATES. A Report on the Polluted Condition of Our Waters and What Is Needed to Restore Their Equality. Public Health Service Publication No. 64. 44 pages. 23×29 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 35 cents.

ANNUAL REPORT OF THE NATIONAL FOUNDATION FOR INFANTILE PARALYSIS FOR 1950. 96 pages. 14×21.5 cm. 120 Broadway, New York 5, N. Y.

A DESCRIPTIVE AND EVALUATIVE BIBLIOGRAPHY OF MATHEMATICS FILMS, by Anthony Benedict DiLuna, Raymond Fenwick Fleet, Jr., and Milfred Kenneth Hathaway, Jr. Mimeographed and Loose-leaf. 96 pages. 22×28 cm. Henry W. Syer, Boston University School of Education, 332 Bay Road State Road, Boston, Mass. Price 75 cents.

BILLY MAKES A HOME FOR FISH, A Science Activity, by O. J. LuPone and Edward P. Powers. Illustrated by Gwen McCormick. Paper. 16 pages. 17×24 cm. 1949. Educational Publishing Corporation, Darien, Conn.

DYNOPTIC LABROSCOPES. Catalog D-185. 22 pages 21.5×28 cm. Bausch and Lomb Optical Company, Rochester 2, N. Y.

DEVELOPING MEANINGFUL PRACTICES IN ARITHMETIC. A Third Report by the Committee on Flexibility. Paper. Pages xii+123. 13.5×21.5 cm. 1951. Central New York School Study Council, 219 Slocum Hall, College Place, Syracuse 10, N. Y. Price $2.00.

EINFÜHRUNG IN DIE TECHNISCHE MATHEMATIK, by Dr. Phil. Horst Von Sanden, *Professor an der Technischen Hochschule, Hannover*. Paper. 60 pages. 15×22.5 cm. Walter de Gruyter and Company, Berlin, Germany

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CLEAR-VISION MIRROR

Clear-vision mirror for the bathroom cabinet is electrically heated just enough to keep it free from moisture. The heating element is covered with a layer of conductive chemical rubber which has high resistance to deterioration from heat. Electric current is turned off or on at will.

BOOK REVIEWS

AN AUTOBIOGRAPHY, by Sir Arthur Keith. Cloth. Pages vi+721. 13.5×21.5 cm. 1950. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

This is another of the stories of the life of a great scientist written by the only one who could tell the actual incidents and adventures of his life. It is most interesting throughout, giving many incidents of his early boyhood days on the farm and in the schools of southern Scotland. Later his life was so closely connected with many of the important developments in English science that we become fairly well acquainted with many of the great scientists as he tells his own part in the investigations he has carried on for about a half century and led to the production of his latest book, *A New Theory of Human Evolution.*

After his school days in the local schools and at Marischal College in Aberdeen he held a position or two at which he says he was not too successful, then he was appointed medical advisor for a gold mining company in Siam. Here he also collected plants for Sir Joseph Hooker, Director of Kew Gardens. After spending about three years in the jungles of Siam, feeding quinine to malaria patients including himself, he returned to London to continue his education, receiving his M.D. and F.R.C.S. at the age of twenty-eight. His struggle for a position, living on borrowed funds, always studying, his first low salaried position, are all told because they make up an important element of his life. He seems to feel that readers will want to know the entire story. His courtship and marriage to Cecelia Caroline Gray, and a happy but very busy life for thirty-five years are told in a most interesting style.

In 1908 he became Conservator of the Museum of the Royal College of Surgeons of England, which he held until his health broke down in 1933. In these twenty-five years he continued his research, wrote many articles and books, and delivered lectures at the college and many other universities. Only two of his many books are mentioned here: the *Antiquity of Man* and *New Discoveries Relating to the Antiquity of Man.* Those who visit the Field Museum of Chicago will find his bust in the "Hall of Man" modeled by Malvina Hoffman, also the introduction for visitors written by Sir Arthur Keith. But the end of his conservatorship did not retire him. He continued his research and writing, and today is an active student, author, and authority. So little can be said of the life of a great man in the few words of a book review. The book should be in the library of every scientist. One reading is not enough. It is a great book by a great man.

G. W. W.

A CONCISE HISTORY OF ASTRONOMY, by Peter Doig, F.R.A.C., *Editor, Journal of the British Astronomical Association.* Cloth. Pages xi+320. 14×21.5 cm. 1951. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

This is a book for the general reader of science rather than for the student of astronomy, but he may find much that will be helpful in his study. It starts with the oldest ideas of the astrologers and gives briefly the principal discoveries and contributions to the subject by China, Egypt, Mesopotamia, India, Greece, the Mohammedans, Tartars, and Europeans to the time of Copernicus, Tycho Brahe, and Kepler. Then follows the great advances made by Galileo and his contemporaries, and the use of the telescope. The great Newton with his many physical discoveries and the use of the calculus, the law of gravity, and his studies in optics open the way for the great century that followed. The eighteenth century with the great names of Euler, Lagrange, Laplace and others working on the theory and men such as Halley and Bradley on the observational and experimental side led the world into new fields of thought. Most of a chapter is devoted to the discoveries of William Herschel, the musician who became the great astronomer. Three chapters are used to cover the investigations of the nineteenth century with special attention to the Solar system, spectroscopic

studies, the use of photography, the study of double stars and spectroscopic binaries. Four chapters then tell of the investigations and discoveries of the first half of the twentieth century—the knowledge of the great universes beyond the Milky Way is increasing rapidly. But we cannot take the space to tell much of this. The book gives an excellent review, closing with the "Red-shifts" and the cosmic time scale. It is a book reliable and clear. In reading the reviewer noticed a number of misspelled words which should have been caught in proof reading.

G. W. W.

COLLEGE ZOOLOGY, by Robert W. Hegner, *Late Professor of Protozoology, Johns Hopkins University;* and Karl A. Stiles, *Professor of Zoology, Michigan State College.* Cloth. Pages x+911. 473 figures. 15×22.5 cm. Sixth Edition. 1951. The Macmillan Company, New York. Price $6.00.

A decade or so ago the majority of college students across the country studied Hegner's *College Zoology,* which was for years the standard text in school after school. With the death of Professor Hegner, his text no longer kept pace with advances in the field, and its popularity diminished. Now Dr. Stiles has revised the Hegner text, placing it once again in the competitive position for use in beginning courses in zoology.

This new edition retains the Hegner approach: starting with the simple forms and working up to the more complex. It is argued soundly that this technique follows the scientific method, gives students satisfaction of progressive accomplishment, follows the natural evolution of life, and prepares students for the advanced forms. Yet the flexibility of the text allows each instructor to exercise his initiative and to arrange the chapter sequence to suit his own special needs. Too, the text is written to be of use both to the students who plan to do further study in the field as well as to those who will not take advanced courses in the field.

Those who are familiar with older editions of *College Zoology* will be interested in learning what changes have been made. Briefly and understandably, much of the text has been rewritten to bring it up-to-date, and there has been rewording to clarify the complexity of certain former explanations. There are more than three hundred new illustrations, the majority of them originals by Mrs. Olivia Jensen Ingersoll. All of these illustrations are integrated with the text material, which has increased emphasis in ecology, geographical distribution, natural history, parasitology, human physiology and diseases, and economic zoology. The representative animal is the cat. There are adequate references at the end of each chapter, and the glossary has been greatly expanded.

It is a pleasure to see Hegner's *College Zoology* made usable again, and there is no doubt but that many schools will choose it over existing texts.

GEORGE S. FICHTER
Oxford, Ohio

PRACTICE OF WILDLIFE CONSERVATION, by Leonard W. Wing, *Agricultural and Mechanical College of Texas.* Cloth. Pages viii+412. 14.5×23 cm. First edition. 1951. John Wiley & Sons, Inc., New York. Price $5.50.

The field of wildlife conservation is extremely broad, and although one of the most discussed topics, it comprises a new and little understood science for the classroom. Dr. Wing's new book is an admirable step in the right direction, for it combines the theoretical and the practical. It is a book which can be used by the technician as well as the teacher. The text is clear and concise, so simple, in fact, that the layman can read and appreciate it; and yet it is thorough and detailed in its coverage of the field. There are numerous illustrations accompanying the text.

Dr. Wing is well qualified as author of this new book on wildlife management. He studied and received his Ph.D. at the University of Wisconsin, from the Father of Wildlife Management, Professor Aldo Leopold. Professor Leopold

granted the Ph.D. degree in Game Management to only three students during his many years at the University of Wisconsin, and Dr. Wing was the first. Since then Dr. Wing has been active in all phases of wildlife management work across the country, field as well as academic.

This is surely a significant text and one which many will want to add to their reference libraries even though they do not teach courses in wildlife conservation. For teachers of wildlife conservation, Dr. Wing's new book is a "must."

GEORGE S. FICHTER

BACTERIOLOGY, by Robert E. Buchanan, *Research Professor Emeritus of Bacteriology, Dean of Graduate School,* and *Director of Iowa Agricultural Experiment Station, Iowa State College.* Cloth. Pages x+678. 14×21 cm. Fifth Edition. 1951. The Macmillan Company. Price $6.00.

Bacteriology is one of those sciences with a rapidly expanding field of knowledge; hence, no text can stand long without revision. This new revision of a text which has been used regularly in many bacteriology curricula incorporates all the recent advances made in the field and broadening, as well, the scope of the field covered, yet not burdening it with medical specialties. *Bacteriology* is still a text which can be used for a general introductory course in microbiology, and it measures up to the fine standards set by this text since its first edition in 1913.

The subject material is well organized and well illustrated. The progression of the text material from fundamentals to more complex titles is clearly shown by sketching some of the chapter titles: Chapter 1, The Beginnings of Biology; Chapter 3, How Microorganisms Are Named and Classified; Chapter 11, Preparation and Uses of Culture Media; Chapter 14, Methods of Observation of Certain Physiological Characters; Chapter 22, Chemical Changes of Economic Significance Produced by Microorganisms; Chapter 24, Microorganisms in the Preservation and Processing of Foods and Feeds; Chapter 32, Diphtheria Group, the Genus *Corynebacterium;* Chapter 34, The Intestinal Group or Enterobacteria . . . ; Chapter 42, The Spirochete Group . . . ; Chapter 44, Viruses and Bacteriophage.

Bacteriology appears to be the sort of book which could be easily adapted to classroom and laboratory work.

GEORGE S. FICHTER

TEXTBOOK OF ORGANIC CHEMISTRY, Third Edition, by E. Wertheim, *Professor of Organic Chemistry, University of Arkansas,* Cloth, Pages xii+958. 15×23 cm. 1951. The Blakiston Company, Philadelphia 5, Pa. $5.00.

This is the third revision of a well written and widely used textbook of organic chemistry. It is organized along traditional lines. The first nineteen chapters treats the aliphatic compounds while the remaining 21 chapters cover the aromatic compounds.

In the first chapter quite a few basic concepts are described, including types of valence bonds, electronegativity, and inductive effect. Later on as various topics are developed use is made of these concepts; for example, the inductive effect is used in chapter eight to explain the increased ionization of certain alpha substituted acids.

Some attention is given to the mechanism of reactions. However, the author should be complimented for not having over-emphasized this subject since beginning students are easily confused by too much space devoted to reaction mechanisms. In order to avoid such confusion the author has placed quite a number of the reaction mechanisms as an appendix in the last chapter and suggests that they had been—"collected in this chapter for ready availability."

Excellent "Review Questions" and "Literature References" are found at the end of each chapter.

The reviewer feels that an excellent first year of organic chemistry could be built around this textbook. However, he cannot fail to observe that the third

edition contains some 120 pages more than did the first edition of this textbook. There is too great a tendency at the present time to make beginning organic texts encyclopedic in nature. The author recognizes this fact in his preface to the Third Edition where he says "several of the longer chapters are intended for reference purposes and will be so used by most instructors."

GERALD OSBORN
Western Michigan College
Kalamazoo, Michigan

BASIC ORGANIC CHEMISTRY, by J. Rae Schwenck and Raymond M. Martin, *Sacramento Junior College, Sacramento, California.* Cloth, Pages ix+323. 15×23 cm. 1951. The Blakiston Company, Philadelphia 5, Pa. $4.50.

This textbook has been planned for a one semester course in organic chemistry. The authors state "that it is not a 'boiled down' edition of a text prepared earlier for majors." The text is intended for use in such preprofessional fields as medicine, dentistry, agriculture, home economics and certain fields of engineering.

The first chapter deals with the electronic structures of carbon and some of the simpler atoms. In this way the authors hope to "correlate Organic Chemistry with the principles of General Chemistry." Chapters two through eleven, deal with the acyclic or aliphatic compounds while chapters thirteen through seventeen treat the aromatic or cyclic compounds. Chapter twelve takes up the subject of nomenclature while chapters eighteen, nineteen and twenty describe both industrial and biological developments in organic chemistry. In addition, the appendix includes a few pages entitled "Warfare Developments in Organic Chemistry."

In order to avoid confusion the authors have used the I.U.C. system of nomenclature throughout the text. However, in chapter twelve the student is introduced to other methods of naming organic compounds. The early historical methods as well as the substitution methods are explained and illustrated.

Excellent study and review questions are found at the end of each chapter. In order to arouse student interest a "Chapter Prologue" is found at the beginning of each chapter.

In the main the book is well written and I feel the authors have accomplished their objectives. To the reviewer who has done most of his chemical research in the field of "free radicals" the absence of any mention of this subject was somewhat of a shock but in a brief one semester course some topics must be omitted. I feel the addition of some appropriate references at the end of each chapter as well as the inclusion of a few pictures of men who have made outstanding contributions to organic chemistry might well be included in textbooks of this character.

GERALD OSBORNE

MATHEMATICS, A FIRST COURSE, by Myron F. Rosskopf, Harold D. Aten, and William D. Reeve, with drawings and special photographs by Harold K. Faye. Cloth. Pages vi+472. 15×22 cm. McGraw-Hill Book Company, Inc., New York, N. Y. 1951. Price $2.60.

This text covers essentially all of the material in a first year algebra course. In addition there is selected material from the fields of geometry; statistics, personal, government, and business finance; elementary trigonometry. There is special emphasis on applications. The book contains an extremely large number of problems—the publishers state there are more than five thousand. In fact, in some places the book seems to be more a collection of problems than a text. On the other hand, some of the treatment is exceptionally good and clear. Possibly because of the large amount of material there are places where the book seems crowded and one gets the impression that a very great deal of material is being presented in a small space. In considering this book for a text one needs to consider the particular type of course. In some situations it is indeed doubtful

that all of the material could be presented. In general this reviewer found relatively little to object to. On page 57 there is a good discussion of why it is impossible to divide a non-zero constant by zero. It would not have taken much additional space to discuss the problem of dividing zero by zero, thus completing the demonstration of the impossibility of using zero as a divisor. Page 105 contains a statement that a protractor marked from 0° to 180° is used for measuring angles; it is also true however that some protractors are graduated from 0° to 360°. In common with many books, the student is asked to construct a formula which can only be valid when the independent variable takes on integral values yet the student will arrive at a formula apparently valid for all values of the variable (an example is problem 6 on page 146). There is an exceptionally fine presentation of the advantages and disadvantages of the arithmetic mean, the mode, and the median. On page 237 it might have been desirable to have pointed out that the installment interest formula given is an approximate one only valid under certain assumptions. Again in connection with interest, on page 244 it is stated that a savings bond earns compound interest at a rate of about 2.9 per cent—this needs to be qualified by a statement as to how often the interest is compounded. The discussion of the solution of quadratic equations by factoring does not mention the fact that this method will not always work. On page 413 the restriction should have been added that the definition of a negative exponent is only valid when the base is not zero. A statement on page 429, "One always arranges to have the decimal part of the logarithm positive . . . " is not true. Usually this is the practice but in later mathematics the student will encounter situations where this is not done. There is no reason for making a statement in an elementary text which must be corrected later. It might be correctly stated that "In this book we shall always arrange . . . " or "For our purposes we find it convenient to arrange. . . . " If we accept the definition (on the same page) that the mantissa is the positive decimal part of the logarithm it would seem to follow that such numbers as 10, 100, 1000, etc. have logarithms without a mantissa.

This is not a book designed for the student who in the opinion of the school cannot master a traditional course in algebra or geometry. The teacher seeking a sound text, covering a broad field, would do well to examine this book with care.

CECIL B. READ
University of Wichita

DIFFERENTIAL EQUATIONS by H. B. Phillips, Ph.D., LL.D., *Professor Emeritus, Massachusetts Institute of Technology.* Third Edition Revised. Cloth. Pages viii+149. 15×21.5 cm. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. 1951. Price $3.00.

The publishers point out that in this revised third edition problem lists have been expanded, some sections have been rewritten, and additional illustrative examples are provided. This would be classified as a somewhat standard text for a first course in ordinary differential equations, with emphasis on applications rather than theory although this does not mean that all theory is neglected. The author emphasizes several points often overlooked by a student, for example, the possibility of losing a solution when a differential equation is divided by a factor containing the variable. In discussing change of variables, he points out in some cases the reason for the choice of a new variable rather than merely stating the procedure as a formal method which yields results. Both students and teachers may be interested in the applied problem on page 99 which relates to rocket propulsion. There is an adequate supply of problems, with answers furnished to essentially all exercises. This text should by all means be considered when a new adoption is taking place and where the course tends to emphasize practical viewpoint as contrasted to the theoretical.

CECIL B. READ

ALGEBRA, ITS BIG IDEAS AND BASIC SKILLS, by Daymond J. Aiken, *Head of Mathematics Department, Lockport Township High School, Lockport, Illinois,*

and Kenneth B. Henderson, *Associate Professor of Mathematics Education, University of Illinois.* Illustrations by Dick Graham. Cloth. Pages xv+409. 16×24 cm. Harper and Brothers, New York, N. Y. 1950. Price $2.48.

As a teacher who first studied algebra more than a generation ago, one is filled with regret that he could not have studied from as attractive a book as this one; as a college teacher one would be indeed happy if students grasped the material presented in this text. The organization is around concepts which the authors call "big ideas." There are seven of these concepts: general numbers, equations, signed numbers, dependence and relationship, graphical representation, exponents, and indirect measurement. A particularly interesting feature is the cartoon type illustrations which at times present new concepts, again emphasize proper methods, and still again point out common mistakes. At various places one encounters a set of "merry-go-round puzzles" which certainly should prove attractive to the student. The typography is excellent; at no place do the pages appear crowded. Only one minor misprint was noted (at the bottom of page 301). The authors are careful to impose proper restrictions; for example it is stated that division by zero is meaningless; on page 316 it is emphasized, in defining a zero exponent, that the base may not be zero (on the same page one wonders why the same restriction was not stated in the definition of a negative exponent). This reviewer gained some new information on page eleven when he discovered that the word *coefficient* means "cooperating with." Reference to a dictionary confirmed this—whether or not this adds to the understanding of the mathematical term *coefficient* might be debatable. The treatment of graphical representation seemed extremely good; there is a good presentation of the slope-intercept method of graphing. There are a couple of pages of interesting notes on the history of mathematics; although some authorities might not agree with all the statements made, there is no gross misinformation presented and the student will doubtless find the items attractive.

In common with many books there is a treatment of the topic of order of operations, introduced by the expression $6+4\times3=?$ Although this topic seems a favorite one the student will rarely encounter in later work any problem which requires a decision as to the order of operations—any ambiguity is usually cleared by use of parentheses or other symbols. There is an excellent discussion of how to discover formulas from tables which essentially uses the concept of first and second differences although not mentioning these by name. One minor point might be raised in that the authors do not strongly emphasize that a constant difference in successive values of the dependent variable indicates a first degree relationship *provided* there is a constant difference in successive values of the independent variable. Following a common mistake in elementary texts, there are at least two cases (problem 22, page 177 and the illustrative example on page 181) where a discontinuous function is graphed as though it were continuous. A good student may see that the formula $C=30n$, representing the cost of n tickets at 30 cents each is meaningless unless n assumes integral values. Again following the custom in many texts, a large majority of the equations have answers which are either integers or simple fractions. If we expect the student of mathematics to develop logic he can well reach the conclusion that any solution of an equation which is not an integer or a relatively simple fraction is erroneous because he has never encountered an equation with an answer other than of this type. In actual practice the engineer takes the other attitude—since such answers almost never occur; he assumes a solution wrong if it comes out a whole number.

Since in the supplementary material the student is shown how to solve second degree equations which will not yield to factoring it might have been valuable to point this fact out when the subject was introduced on page 244. After an excellent treatment of graphical methods, it is a little disheartening to find in problem 40 on page 250 the statement "Solve . . . both graphically and algebraically. . . . " This would seem to imply that the graphic solution is not algebraic—why then, is it treated in a text in algebra?

All the criticisms mentioned are relatively minor, and perhaps represent prejudice on the part of the reviewer. The book as a whole is unquestionably superior and by all means should be considered in connection with a change of text.

CECIL B. READ

COLLEGE ALGEBRA by Herman K. Fulmer and Walter Reynolds. *The Georgia Institute of Technology.* Cloth. Pages vi+204+xiv. 15.5×24 cm. Ginn and Company, Boston 17, Mass. 1951. Price $2.85.

This text is planned for a brief course in college algebra which gives a review of the essentials of elementary algebra and carries the student into a discussion of the theory of equations. There is no treatment of statistical measures, permutations and combinations, or probability. The properties of determinants are given without proof, but with illustrations in the case of the third order determinant. The treatment of partial fractions is quite brief, and in the opinion of the reviewer, seemed to emphasize mechanical procedures rather than to give an understanding of the reasons for such procedures. Horner's method is offered in connection with the solution of higher degree equations, contrasting with the treatment in many brief algebras, which emphasize a graphical method. Answers are provided to all exercises. In general, the number of exercises seems moderately adequate, but in some cases it might have been better to have provided additional exercises. Some of the exercises seem exceptionally well selected; for example, many problems are provided resembling expressions which arise in calculus when differentiating quotients or products. There are other problems which would aid the student in setting up problems in maxima and minima. In a few cases the discussion might have been improved. For example, on page 29 it is stated that 0/0 "is also undefined" without any discussion of the reason for this. On page 56 a reference is made to a further discussion in section 56, but the section referred to does not clearly show that it is an extension of the earlier material. In treating Descartes rule of signs on page 166 the authors apparently overlook the fact that their previous definition of $f(x)$ did not require that the coefficients be real, hence it does not follow that for any $f(x)=0$ imaginary roots appear in pairs. Logarithms are treated in the last chapter of the book. The sections on exponential equations and on natural logarithms seem extremely brief.

For any one wishing a short course in college algebra, this book merits consideration. It does give considerable review of earlier work, although as pointed out, it is not as complete in treatment of new topics as some books on the market.

CECIL B. READ

THE FOURIER INTEGRAL AND CERTAIN OF ITS APPLICATIONS by Norbert Wiener, *Professor of Mathematics at the Massachusetts Institute of Technology.* Cloth. Pages xi+201. 14.5×21 cm. Dover Publications Inc. 1780 Broadway, New York 19, New York. First American printing of the 1933 edition. Price $3.95.

This is another of the reprints of out of print mathematical books which have been issued in the past few years by the Dover Publications. This book would be classified as a monograph rather than a textbook. As might be expected, in order to follow the book one needs a rather thorough grasp of mathematics through advanced calculus. In the introductory chapter the author summarizes some of the important properties of the Lebesgue Integral. There are essentially no illustrative examples or applied problems. Those interested in a more detailed review than is warranted in this publication might consult the bulletin of the American Mathematical Society, Volume 41, pages 595–597 (September, 1935).

CECIL B. READ

JOHANNES KEPLER: LIFE AND LETTERS, by Carola Baumgardt (with an Introduction by Albert Einstein). 209 pages. Bibliography. Index. Philosophical Library 1951. $3.75.

I have always held that candidates for degrees in science at all levels of attainment—bachelor, master, doctor—should show a sensible command of the ***history*** of the subject. ***This reduces essentially to a knowledge of the men who made it.*** This humanistic approach has often been scoffed at by the scientist and the science teacher, the argument being that such stuff "waters down" the course they teach! This strikes me as a ridiculously weak contention. (See my note in the *American Journal of Physics*, February 1950, page 115.)

The best device for promoting the end I propose is a reading of the biographies of the great. There are many excellent ones—on Newton, on Rutherford, on Faraday, on Pasteur, on Galileo—this one on Kepler is eminently beautiful. It is a deeply moving story of one of the great men of all time, the father of modern astronomy. The travail and hardship which Kepler endured, although not unique, is revealing of the essential and intrinsic greatness which the man possessed. And as Einstein says in his elegant introduction, these things have enormous significance for our own times.

The biography is centered around the correspondence which Kepler had with laymen, scholars, and nobility and as such brings to us the ***primary*** sources which we so seldom meet. These letters are beautiful to read.

JULIUS SUMNER MILLER
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ESSAYS ON LOGIC AND LANGUAGE, edited by Antony Flew (Oxford); 206 pages; Philosophical Library 1951. $3.75.

This is a collection of philosophical articles by eight scholars on the problems of *logic and language*. It is only since the turn of the century that serious attention has been given to this quarter of human knowledge, and although a goodly literature exists on the subject it is within the grasp of very few. Philosophical essays are generally not digestible unless one is especially schooled. On this subject in particular is the language erudite and heavy and the Editor has done a service to bring together a few scholarly papers which are eminently readable.

This linguistic movement in philosophy is best described by a quotation from John Locke in "An Essay concerning Human Understanding": "Perhaps if ideas and words were distinctly weighed and duly considered, they would afford us another sort of logic and critic than what we have hitherto been acquainted with." The problem specifically to which these philosophers give their attention is the detection of the sources in linguistic idiom of misconceptions and absurd theories, and of logically misleading language. "How easy it is to slip into nonsense by even apparently trivial deviations from standard English, how easy it is to use sentences which look all right, which have a close grammatical resemblance to sentences which are indeed proper, but which are nevertheless logically disreputable . . . " (Professor G. E. Moore).

None of the nine essays are especially difficult to follow and several in particular are worth our closest attention. (By 'our' I mean physicists, mathematicians, etc.). By title these are ***Systematically Misleading Expressions; Time: A Treatment of Some Puzzles; Bertrand Russell's Doubts About Induction; The Philosopher's Use of Analogy; Verifiability.***

It is doubtful if any of us outside the domain of philosophy proper would seek out and read these original papers in the journals. This collection brings them to us at small cost and I highly recommend them. Several of the essays lend themselves indeed to a physics colloquium.

JULIUS SUMNER MILLER

MUSICAL ACOUSTICS, by Charles A. Culver, ***Visiting Professor of Physics, Park College; Formerly, Head of the Department of Physics, Carleton College.*** Third Edition. 215 pages. 148 illustrations. Blakiston 1951. $4.25.

Professor Culver's book is probably ***the*** standard in English in its field, especially as far as course work goes. The first edition has had an enviable record

in the past decade. It was designed for musicians and for use in a one-semester course. It is a beautiful treatment of the physical basis of music.

As the author puts it in his preface: "It should be obvious that no serious student of music can afford today to remain unacquainted with the basic physical laws of acoustics. . . . "

Apart from its usefulness to the musician and to the college music major it is a highly readable book for general enlightenment. The exposition is clear and the illustrations are highly instructive. "No mathematics except simple arithmetic is needed." This detail alone will undoubtedly recommend it to those who do not yet know it.

This new edition treats the English horn and the harp, and Vibrato and Masking are introduced. References appear in the body of the text and should be pursued by the serious student.

Every music-listener would profit immeasureably from this exposition. The music major should feel it a mandate upon himself if a formal course is not available to him.

JULIUS SUMNER MILLER

SPACE—TIME—MATTER, by Hermann Weyl. Translated from the German by Henry L. Brose. First American Printing of the 4th edition (1922). 330 pages. Dover Publications. $3.95.

This classic (Raum Zeit Materie) appeared in its first edition in 1918 and I doubt if there is a single self-respecting physicist who does not know it! Those who do not should go to it at once. The translation (1921) cannot be excelled.

The relativity theory here expounded deals with the space-time aspect of classical physics. In this respect then, the treatment is little affected by the quantum physics of the past thirty years. Professor Weyl suggests however, that if he were to write the book today "he would take into account certain events that have modified the situation in the intervening years." By these certain events he means the new gravitational field theory, quantum physics, and unified field theories in general.

There is little point in "reviewing" this book. *Classics need no commentary from a reviewer!* The serious student of physics, philosophy, and mathematics must stand indicted if he does not know this volume. In the days when classical physics was studied—everybody studies nuclear physics *now*—this was as good a preamble to Relativity as the literature provided. It is no less so now.

JULIUS SUMNER MILLER

PLANE TRIGONOMETRY, by John J. Corliss, and Winifred V. Berglund, *Chicago Undergraduate Division, University of Illinois.* Cloth. Pages xii+388. 14×21.5 cm. 1950. Houghton, Mifflin Company, 2 Park Street, Boston, Mass. Price $3.00.

It appears that the authors of this text have taken a long and careful look at analytic geometry, calculus and physics and then have tried to build a text to meet the requirements of the able student who plans to continue his study of mathematics and science. It is heartening to note that they show a genuine concern for logic and a keen appreciation of the value of well drawn definitions. The logic is exemplified in the treatment of identities where it is appropriately pointed out that a theorem cannot be established by proving its converse. The following language is used: "If we start with some expression and after a series of seemingly logical steps end with an identity, this does not prove that the given expression is an identity. The actual proof consists of starting with an identity known to be true and ending with the equation in question." Most instructors will agree that this point requires considerable emphasis. As an example of the carefully drawn definitions which anticipate more advanced ideas consider the definition of function used in this text: "Suppose we are given two sets of numbers whose individual members are represented by x and y respectively. If x and y are so related that to each number x of one set there corresponds one or more

numbers y of the other set, then y is said to be a function of x." Here, surely, is a concept which represents a considerable advance over the vague, intuitive notions usually found in earlier courses. This concern for logic and careful attention to definition makes it possible for the student to develop that appreciation for rigor in mathematical argument which is so necessary for advanced work.

The sequence of topics is somewhat unconventional but quite defensible. Radian measure, directed line segments and polar coordinates are considered in the first two chapters. The definition of function noted above is followed in chapter three with the generalized definitions of the trigonometric functions in which r is regarded as negative if it lies on the extension of the terminal side. Chapters four and five deal with graphs of the functions and the right triangle. An excellent graphical interpretation of linear interpolation is presented here together with some appropriate remarks about approximate computation. It must be noted, however, that the conventions for computation which are adopted at this point would seem to have the effect of minimizing the students' actual experience with approximate computation. Chapter six contains an excellent assortment of problems involving practical applications of elementary vector analysis. In addition to the usual work on navigation one finds carefully presented definitions and theory concerning such concepts as friction, torque and conditions for equilibrium. Such analyses are seldom found in trigonometry textbooks of recent vintage and thus their inclusion here does much to make the related problem material realistic and challenging. The remaining nine chapters deal in order with logarithms, reduction formulas, fundamental identities, trigonometric equations, inverse functions, functions of two angles, oblique triangles and complex numbers. There are about 800 well chosen exercises of a wide range of difficulty some of which are highly ingenious. For example, there is an excellent section on the practical applications of complex numbers. The usual five place tables are included together with a four place table of the natural functions with conversion to radians and a table of squares.

The work on reduction formulas is worthy of note as being representative of the rather neat presentations which abound in this text. For example in finding the functions of a negative angle, it is shown that for corresponding points in the terminal sides of $-\theta$ and θ we have $r'=r, x'=x$ and $y'=-y$, from which the functions of $-\theta$ can be written at once in terms of the functions of θ. A diagram is used but it is really unnecessary to carry the argument.

This text not only emphasizes the topics which form the basis for advanced work, it also, through its methods of presentation, makes a serious effort to condition the student's mind for the kind of thinking necessary for effective study at higher levels. Yet it is not a difficult treatment and appears to be quite teachable.

Frank B. Allen
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Self-watering flower pot, a plastic decorative device for use in the home, is rectangular in shape and fits into a black plastic water-holding base. A wick through the bottom of the vase carries water to the plant roots by capillary action. One filling of water lasts a week.

"Spectrosphere" is a cylindrical chamber with a viewing window for comparing the brilliance and fire of gem stones, the presence of single or double refraction and variation in the dispersion of light between different stones. The gem rotates during the reviewing.

THE NEWARK MATHEMATICS FAIR

Last year the teachers of mathematics in the secondary schools of Newark, N. J., felt the need for joining together in assaulting the problems which beset secondary mathematics today, both on a local and national scale. Several meetings were held culminating in the formal organization of the Newark Council of Teachers of Mathematics. The two major program meetings for the year brought forth first a lively discussion of the new Ninth Year Mathematics Curriculum in Newark, and secondly, an interesting talk and discussion led by Prof. Howard Fehr, Head of the Mathematics Department, Teachers College, Columbia University, on "The Gifted Pupil in Mathematics."

The Program Committee, under the leadership of Ernest R. Ranucci, Head of the Weequahic High Mathematics Dept. then embarked on our first major project, a Mathematics Fair. Enlisting the aid of our members and their students, the Mathematics Dept. of Montclair State Teachers College, especially instructor George Kays and some of his students; and the facilities of Arts High School, made available by its principal, Frederick Seamster, the committee gathered sufficient material of interest to make April 25, 1951 a red-letter day for mathematics in Newark.

At tables in the Gym were displayed many mathematical models and applications, geometric designs and drawings. Two notables among the hundreds of visitors were Michael McGreal, Asst.-Supt. of Schools in Newark and Dr. Virgil S. Mallory, Head of the Math. Dept. of M.S.T.C. Later, in the auditorium, after a welcoming address by Harold Gouss, Pres. of the N.C.T.M., Mr. Ranucci introduced speakers on the abacus, soap film experiments, history of mathematics, and the making of artistic geometric models, the three former being students, the latter Charles Goeller, instructor at the Newark School of Fine and Industrial Arts.

The finale of the program was a quiz conducted by Max Sobel teacher at Robert Treat Jr. High. All visitors received mathematical programs and the contestants in the quiz were awarded prizes, the winner receiving a slide rule plus ten "humorous" rules for its use.

As an initial effort in the stimulation of interest in mathematical education in Newark this Fair became, by virtue of the cooperation it engendered among all those involved, an inspiration for future plans along this line. In addition to those already mentioned special thanks should be given to other members of the program committee: Miss R. Meyerson of Cleveland Jr. High, Mrs. E. Katz of Webster Jr. High, Mr. N. Chinoy, and Mr. P. Clammurro both of Arts High. The new officers elected for the year 1951–1952 are

Pres.: Harold A. Gouss of Central High
Vice-Pres.: Max Sobel of Robert Treat Jr. High
Treas.-Sec.: Ruth Meyerson of Cleveland Jr. High

THE SONOTEST

The Radiological Corporation of America has announced the availability of a new instrument for the measurement of ultrasound intensity. Produced by the world famous Siemens-Reiniger organization, this instrument, called "SONOTEST," should find wide application in any research laboratory concerned with the investigation of ultrasonic effects.

The Siemens SONOTEST indicates the transmitted ultrasonic power on a scale calibrated directly in Watts. The average intensity in Watts/cm.^{2} is easily obtained by dividing the integral power reading (total Watts) by the transmitting area of the respective irradiation head (cm.^{2}). The instrument in effect measures the mechanical sound radiation pressure.

The SONOTEST can be used for under-water measurements and will give indications in any desired position. The range of the meter is from 0 to 60 watts. Readings are subject to an error of less than $\pm 5\%$ within the frequency range from 0.175 Mc/sec. to 2.4 Mc/sec.